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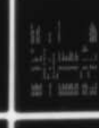
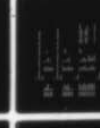
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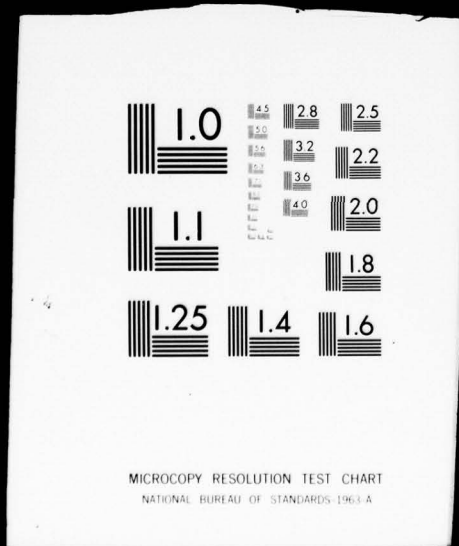
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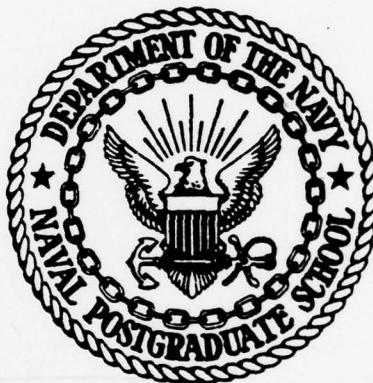




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sixteen analog inputs simultaneously at rates in excess of 45,000 samples per second. The experimental data could be transmitted expeditiously to the IBM 360 computer for efficient manipulation. Additional benefits gained from the system were its capabilities as a remote terminal for the IBM 360 and a typewriter-quality word processor. The data acquisition and reduction system was qualified for functional performance and speed through a series of test exercises. The word processor was demonstrated in the production of this document.

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HIGH SPEED DATA ACQUISITION SYSTEM

by

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Lieutenant, United States Navy  
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Submitted in partial fulfillment of the  
requirements for the degree of

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

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## ABSTRACT

This paper describes the expansion and modification of an existing data acquisition system to effect extensive improvements in speed and flexibility. A microprocessor, flexible disk drive, analog to digital converter, direct memory access module, and high-speed line printer were integrated and interfaced to an IBM 360 digital computer with a high-speed data transmission line.

The resultant system provided the capability of digitizing up to sixteen analog inputs simultaneously at rates in excess of 45,000 samples per second. The experimental data could be transmitted expeditiously to the IBM 360 computer for efficient manipulation. Additional benefits gained from the system were its capabilities as a remote terminal for the IBM 360 and a typewriter-quality word processor. The data acquisition and reduction system was qualified for functional performance and speed through a series of test exercises. The word processor was demonstrated in the production of this document.

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## I. INTRODUCTION

The advent of the low-cost microprocessor system has made possible the conduct of numerically controlled laboratory experiments such as described by Casko, Ref. 11. An equally important application is in data acquisition and analysis. The ability of the microprocessor to accommodate many different tasks by software (program) changes has resulted in a very flexible system for an academic laboratory environment. Because of the relatively low cost of a complete microprocessor system, which should more aptly be termed a microcomputer, it is now practical to do experiments in aeronautics with an orientation toward investigating unsteady or time varying physical behavior. Recent experiments on the Circulation Controlled Airfoil, as reported by Englehardt in Ref. 1, are an example of the type of work which can be done economically in establishing the frequency response behavior of aerodynamic configurations.

In improving the experimental capabilities of the microcomputer system in the Department of Aeronautics, several features became evident as desired goals. Included in these goals were:

A. To extend the useful frequency range for data acquisition by verifying the Analog to Digital (A/D) sampling rate potential of an existing system data card as being on the order of 40,000 samples per second for situations of routine usage.

B. To upgrade the use of output printing devices to a typewriter-quality line printer with a maximum output baud rate of 9600 in comparison to the more common Teletype Model ASR-33 or ASR-35 baud rate of 110.

C. Although the microcomputer system had an internal computational package allowing the option of software programming for data reduction in BASIC language, it was desirable to link the microcomputer system to the IBM 360/67 digital computer at the W. R. Church Computer Center for increasing the scope (both complexity and speed) of data reduction for digitized data sets.

This thesis describes the approaches taken to achieve the above stated goals in order to improve both system flexibility and computational speed while retaining the advantages of local autonomy and cost effectiveness provided by the use of a microcomputer system.

## II. HARDWARE

The original concept of the microcomputer or micro-processor involved the design of a low-cost compact version of the large digital computers. According to Osborne, Ref. 12, the resultant design differed from the goal primarily due to the distribution of logic on integrated circuit chips. Some differences in addressing modes and execution times were evident in the microcomputers.

The system used in this project had a sixteen line address bus capable of addressing 65,536 locations (2 to the 16th power). Data processed by the microcomputer travelled over an eight line data bus. The data bus is capable of handling eight binary digits (bits), or one byte, at a time. Similarly the central processor unit (CPU) within the microcomputer can work with only one byte at a time. Although sixteen bit CPU's and data busses have recently been developed, the large number of existing eight bit CPU chips assures us that the eight bit bus will be in usage for quite some time.

Subsequently data processing or numerical manipulation in the eight bit system is a relatively slow and pedestrian process. Numerical accuracy requires representing a number



by several bytes, and in much of our software the floating point binary number is represented by four bytes consisting of exponent, sign, and magnitude. Long cumbersome algorithms manipulate one byte at a time and then collocate the individual results into one total number. The addition of a peripheral device specializing in numerical manipulation, called a "math pack", can expedite the process considerably. However, all input/output operations would still be limited by the eight binary parallel digit capacity of the CPU and data bus.

The approach taken in this thesis was to avoid, to the greatest extent possible, any data manipulation by the microprocessor and instead to use it only as a control for faster peripheral devices. The data manipulation was then accomplished with the IBM 360 digital computer.

#### A. Components

The major components utilized in the project are discussed briefly in this thesis, and detailed descriptions are given in the referenced material. Because of the inherent complexity of integrated circuitry and digital logic considerations, even the reference manuals are often incomplete. Ignorance of a subtle but important detail about a particular component can cause the neophyte student of microprocessor technology to make errors which are

difficult to identify and cause unpredictable results. Emphasis has been put, therefore, on identifying particular idiosyncracies which have been exposed during this project and hopefully the errors need not be repeated.

## 1. Microprocessor

The Intel MDS-800 Microcomputer Development System with central processor unit, 64K of random access memory, front panel controller, and mainframe enclosure has been documented extensively in Ref. 1. The MDS-800 and connected flexible disk drives, CRT terminal, and paper tape reader were the benchmark devices for the project. The system, although not quite state-of-the-art in terms of micro-processors, was nevertheless a well-developed and popular system for which substantial software had been developed.

## 2. Analog to Digital Converter

The Datel Sinetrac-800 Analog to Digital Converter, also described in Ref. 1, was reconfigured according to the specifications in Ref. 2 for use in the Direct Memory Access (DMA) mode. Basically the only changes necessary were disabling the address structure to prevent the CPU from writing to the converter directly, and enabling the circuit board for DMA operation. Parameters left unchanged included the input voltage range of +/- five volts, twelve bit reso-

lution, twos complement output coding with sign extension, and the scan-clock option enabled. The converter digitized each analog signal into two bytes which required two memory locations. The least significant twelve bits provided a resolution of two to the 12th power ( $4096$ ). When applied to the input voltage range, this resolution meant an accuracy of  $\pm 0.002$  volts. The remaining four bits of the digitized input formed a hex digit, either 0 or F, which represented a positive or negative sign. Connection of the external analog inputs to the converter was made via a locally prepared terminal box.

Several options were available for determining the scan repetition rate. The scan-clock option allowed for a hardware variable scan rate but did not provide enough flexibility. Another possibility was to use software control through the CPU but this option was too slow. An approach which provided a greater degree of flexibility utilized the SBC Intel 534 Input/Output board to time the scan intervals, and involved operating the ST-800 on an interrupt basis so the interrupt structure was enabled. The final configuration, however, excluded interrupts by the device, hence the interrupt logic wiring was again disabled.

### 3. Direct Memory Access

The Intel SBC-501 Direct Memory Access (DMA) Channel



Controller board was utilized to greatly decrease the throughput time of analog signal to memory storage. As reported in Ref. 1, the analog to digital converter, when operated under direct program control, had a throughput time of 76.5 microseconds per channel. This relatively slow rate was caused by the necessity of multiple transfers of each word of converted data from converter to CPU to memory with each transfer requiring several time-consuming commands to be issued by the CPU.

According to the specifications in Ref. 3, the DMA controller board was configured for base address and interrupt level and installed in the MDS-800 mainframe. A wiring harness obtained from the Datel Corporation connected the DMA board to the ST-800 converter. The DMA was programmed by the CPU to transfer a specific number of data words from the converter directly to random access memory. Then control of the data bus was relinquished by the CPU and the DMA and ST-800 were allowed to work together at maximum speed. Using full handshaking to avoid data overruns, the ST-800 sampled and converted analog signals which were routed through the DMA directly into memory. The CPU was bypassed and consequently the throughput time was reduced to 21.7 microseconds. Utilization of a pulse generator to initiate each scan gave total flexibility to the data sampling rate within the outside limit of 45,000 Hertz.

#### 4. High-speed Printer

The Teletype Model 40 Printer was chosen to supplement the teletype terminal used in earlier projects. The Model 40 is a chain-type printer capable of 9600 baud (or 960 characters per second). Upper and lower case letters are available as is the option to use a variety of paper sizes. The printer was interfaced through a serial transmission Universal Synchronous Asynchronous Receiver Transmitter (USART) on the Intel SBC 534 board and programmed to use the standard 11 X 14 inch paper stock. Switch selectable options on the printer were set as desired in accordance with Ref. 4. The major problem that occurred when interfacing the printer was an incorrectly wired interconnector in the printer enclosure.

#### 5. Full-sized Digital Computer

The International Business Machines Model 360/67, located in the W. R. Church Computer Center, was interfaced to the microprocessor via an RS-232C driver and telephone line. The interface, called a "high-speed line" because of its improved speed of transmission over earlier connections, was also serially driven by a USART on the SBC 534 board. Operating at baud rate of 1200 baud, the interface provided the capability of transmitting data to the larger computer which was designed for more efficient data manipulation.

The line from the microprocessor fed into the IBM 360 through an IBM 2701 Data Adapter unit controlled by the Control Program-67/Cambridge Monitoring System. Interface requirements that were imposed by the IBM 2701 were obtained from Ref. 5.

## B. Interfaces

The Intel SBC 534 Four Channel Communications Expansion Board, described in Ref. 6, was used to interface the microprocessor with both the printer and the high-speed line. The SBC 534 board was selected because of the flexibility it afforded with regard to future improvements to the system. The board was jumper configured for base address, installed in the MDS-800 mainframe, and connected to the high-speed line and printer by locally prepared wiring harnesses. Two of four serial 8251 USART's and two of six programmable timer circuits on the board were utilized for the interfaces. One Programmable Interrupt Controller (PIC) of two on the board was used in an alternate approach mentioned later, but the final configuration left the PIC disabled. Another circuit available on the board for future use is an 8255 Programmable Peripheral Interface. Exact specifications and operational descriptions of the individual circuits on the SBC 534 board were found in Refs. 7 and 8.

The rates of transmission and reception of data by the

USART's were determined by the programmable timer circuits. The timers were software programmed with the appropriate countdown number and effectively divided the master clock frequency of 1.2288 Megahertz by that countdown number. The outputs of the timer circuits were jumper connected to the Transmit Clock (TxC) and Receive Clock (RxC) pins on the respective USART's.

### 1. Printer Interface

The Teletype Model 40 Printer interface required the consideration of handshaking signals between the USART's on the SBC 534 board and printer to maximize the speed of transmission while avoiding any data overrun. Connections between the SBC 534 and Model 40 were as indicated in Fig.

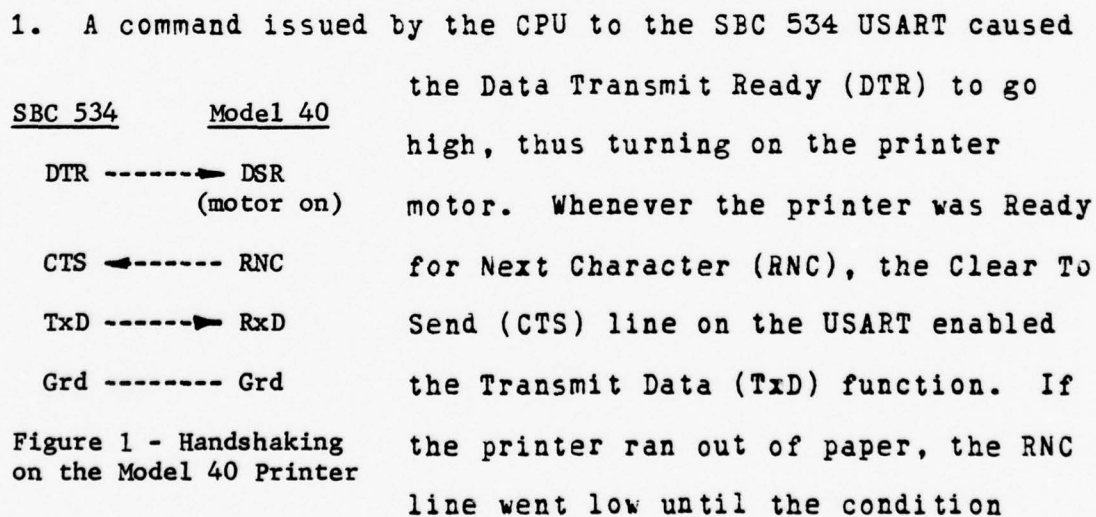


Figure 1 - Handshaking on the Model 40 Printer

was rectified. Since data transmission was one-way from microprocessor to printer, other handshaking facilities were not needed.



Of two one-byte data buffers involved in the transmit function of the USART, one actually transmitted the data words serially (similar in operation to a shift register). This action was enabled by the CTS line indicating that the printer was ready to receive. The second buffer accepted data words from the CPU and loaded the first buffer in parallel at the proper time. The full or empty condition of the second buffer could be determined during program control by checking the value of the Transmitter Empty (TxE) bit in the USART status word.

## 2. High-speed Line Interface

In the high-speed line interface, there was no handshaking between the SBC 534 USART and the IBM 2701 unit.

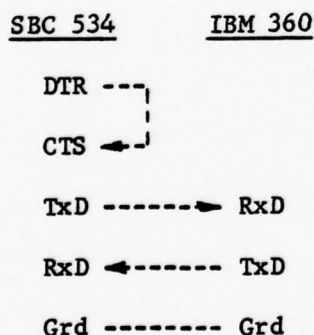


Figure 2 - Handshaking on the high-speed line

The only hardware consideration was how to enable the Clear To Send (CTS) line on the USART. By permanently connecting the Data Transmit Ready (DTR) and CTS lines on the USART, the CTS and thus the transmit data (Tx) function were enabled by setting the DTR bit to high in the command word from the CPU to the USART. The

obvious problems associated with the absence of handshaking were solved through software provisions.

### 3. Analog to Digital Converter Interface

The ST-800 converter was already configured except for minor changes to accommodate DMA operation. It was installed in the MDS-800 mainframe, and connected to the SBC-501 DMA controller board and the analog input terminal. All handshaking between the ST-800 and DMA controller was automatic as described in Ref. 2.

The scan-clock option, which provided for a selectable delay between scans, was enabled by jumper connection. Since an external scan initiation was desired, pin 34 on the ST-800 J2 connector was grounded. Effectively, the scan-clock option circuitry was used to initiate each scan. The actual signal came not from the scan clock, however, but instead from a negative TTL pulse which was input at pin 36 of the ST-800 J2 connector from an external pulse generator.

### 4. Direct Memory Access Interface

The Intel Direct Memory Access controller board was installed in the MDS-800 mainframe and connected to the ST-800 converter. The DMA was set to operate at interrupt level four by adjusting a rotary switch on the board. Upon

completion of a cycle, the DMA generated a signal to the CPU interrupt controller which then stopped program execution in order to service the interrupt.

### III. SOFTWARE

All programming on the project was done using options available under the CP/M (Control Program/Monitor) monitor. This operating system allows the user to manage files on disk and provides the basic input/output facilities necessary to communicate with peripheral devices. System utilities allow the user to create, edit, load, run, and record programs on the diskette. Two powerful programs, the Macro Assembler (MAC) and the Symbolic Instruction Debugger (SID), give the user vast capabilities to assemble and monitor programs at execution in order to easily detect errors. The system is a product of Digital Research and is described in Ref. 10.

The programming language options available were assembly language and PL/M. Assembly language is shorthand notation for machine language which allows mnemonic instructions, with a one-to-one correspondence between each assembly instruction and a machine code instruction. Because of this, assembly affords direct control over the working registers of the central processor unit; however, for the same reason even simple jobs for the microprocessor can result in long and complex programs. Programs must first be assembled, whereby the assembly mnemonics are compiled into



hex code and addresses are assigned to symbols. Next the program must be loaded, or converted to binary code, before execution by the microprocessor. The only alternative is the PL/M language which is somewhat more sophisticated but which, when reduced finally to binary code, results in about a twenty-five percent waste of memory. The 8080 assembly language was therefore used in all programs during this project.

All assembly programs devised for this project required the use of large memory buffers, so efficiency of programming was paramount in order to reserve as much memory space as possible. For the commonly used 48K system, for example, the memory locations 0-100H and A900H-BFFFH were used for the operating system code. If the user program occupied storage locations 100H-1000H, only 39,078 locations (A900H-1000H) remained available for data storage.

Another observed disadvantage of the assembly language was that the programs were difficult to follow even when well-documented. For this reason, all the programs were designed to be "user oriented" with a multitude of prompts and explanatory comments being echoed to the CRT. Additionally, the programs were heavily documented and instruction guides written for each interface.

The software which interfaced the analog to digital converter, high-speed line, and printer to the micro-processor could all be classified as monitor and control programs. The peripheral devices were monitored and controlled by the central processor unit while keeping the user informed via the CRT.

#### A. PRINT Program

The PRINT program searches the disk for a specified file, loads the file into memory buffer, and outputs the file to the Model 40 Printer. While outputting the file, PRINT also creates a format for the standard 11x14 inch paper, numbers the pages, and heads each page of printout with the given filename and filetype. If desired by the user, the PRINT program will double space the output; this option works in conjunction with the single/double space switch inside the printer cabinet. PRINT is compatible with all ASCII filetypes.

Another option allows the partial printout of a file between two specified strings of data. This feature is especially useful when working with large files and conserves both paper and time.

Most source files residing on the user's disk are not pre-formatted, hence the PRINT program produces a neat,

orderly output with numbered and titled pages. Certain files, however, including PRN files generated by the Macro Assembler or the Tex Formatter, have already been formatted for a similar output. In order to avoid double formatting, an option exists in the PRINT program whereby the user is queried whether the named file is already formatted. An affirmative response causes the formatting and page numbering features of the program to be suppressed.

#### 1. Printer Control

The program's first task is to initialize the printer and to output data at a rate commensurate with the printer's ability. The CPU first sets up the appropriate timer on the SBC 534 board to pace the binary output at 9600 bits per second. Next the USART is commanded to transmit seven bit words (the eighth bit is zero for all ASCII characters) with one start bit, one stop bit, and no parity bit. The entire serial word train involves ten bits of data. Additionally the CPU command resets any USART error flags and drives the DTR line high, thus turning on the printer motor.

Once the USART is initialized, the CPU reads its status and checks the condition of the Transmitter Empty (TxE) flag. As soon as the transmitter buffer is determined to be empty, the CPU outputs the next data byte.

## 2. File Reading

Using CP/M system functions, the file to be printed is found and read from the diskette. Since the CP/M disk read function reads 128 byte blocks of data at once, another CP/M function is used to increment the memory location by 128 for each block of data read from the diskette. This process continues until the byte "1AH" is encountered signifying the end of file (EOF).

## 3. Formatting

Counters are maintained to limit each line to 131 characters and each page to 55 lines. At the beginning of each page the page number, filename, and filetype are output. At the end of each line the keyboard is checked for a user interrupt. The process continues until the end of file (EOF) byte is again encountered. At this time the program turns off the printer motor and returns to the CP/M environment.

## 4. Prompts

Once the program is executed, user prompts flow sequentially to the CRT and the responses are checked for reasonableness. Any problems associated with incorrect responses, file reading, or control of the printer result in

automatic error messages to the console.

## 5. PRINT User's Guide

The PRINT User's Guide was intended to be used as an independent manual. The guide provides detailed operating instructions for the Model 40 Printer interface and is included as Appendix E. A listing of the PRINT Assembly program is included as Appendix I.

### B. LINK Program

Programming for the high-speed line interface was difficult because the absence of handshaking on the line presented some unique problems. When transmitting from the microprocessor to the IBM 360, the rate and regularity at which data words were output were of no significance. The IBM 2701 unit received one complete line before answering. Upon receiving a byte "13H" (XOFF) signalling the end of a line, the 2701 unit answered with a sequence of bytes: "0DH" (carriage return), "0AH" (line feed), "00H" (null), "3EH" (CMS prompt ">"), and "11H" (XON). Any information transmitted by the IBM 360 always preceded this exact sequence. The programmed arrangement was, therefore, that each unit would take turns transmitting and receiving.



More complicated provisions had to be inserted into the program, however. If the microprocessor attempted to transmit a line containing more than 132 characters, the 2701 unit rejected the excess characters and interrupted with an error message. Also there were occasional instances when the IBM 360 output a large number of lines without the XON. For example, if commanded to print a FORTRAN file, the IBM 360 would output the entire file before transmitting the XON. Therefore, the capability of interrupting the IBM 360 was needed. Instead, the control program had to allow for reception while transmitting and for transmission while receiving.

This was accomplished by setting up two separate loops for the transmit and receive functions. When involved in the reception of characters, the microprocessor CPU constantly checked the keyboard for a user interrupt. If one were found, the program immediately issued a pair of XON characters to the 271 unit while still receiving characters. When the 2701 received the XON's, it acknowledged the interrupt with the usual sequence.

When involved in the transmission of characters, the CPU constantly checked the receive buffer for a data word. When one was found, the program control reverted to the receive function.

## 1. USART Setup

The USART and timer for the high-speed line were set up similarly to the printer USART. The timer was commanded to generate a baud rate of 1200 baud and the USART was commanded to both transmit and receive. The transmitted serial word train contained one start bit, seven data bits, and two stop bits. The only available baud rate on the high-speed line was 1200 baud. Future improvements to the rate are discussed in the conclusion section to this thesis.

## 2. Monitor Function

When executed, the LINK program was in the receive status. After receiving the first transmission from the IBM 360, program control went into the transmit function. While in this status, the CPU program alternated between checking the receive buffer for an interrupt and checking the keyboard for a user input. Upon receipt of a user input, the CPU screened the input for certain control characters and, if one were found, branched to the proper subroutine. This monitor function was designed so that control characters used during CP/M operation could also be used when operating with the IBM 360 under CMS. User inputs that were not control characters were output to the IBM 360.

A Control I, the tab command under CP/M, was transmitted to the IBM 360 as a "?" which should have been previously defined to CMS as a logical tab character. A RUBOUT was transmitted as a CMS delete character symbol and a Control U as a delete line symbol. A Control R or Control T caused program control to branch to subprograms that effected the transfer of complete files between micro-processor diskette and IBM disk. Similarly, a Control P caused control to branch to a routine that turned on the printer if off and vice versa. This allowed the user the capability of echoing all correspondence with the IBM 360 to the printer.

If a Control C were input, the program control instituted a soft boot and returned the user to the CP/M environment. The high-speed line was still active although the LINK program was no longer in service. Any transmissions by the IBM 360 at this time "fell on deaf ears". A Control G caused the program to print on the console a list of all Control functions.

### 3. Data Buffers

Although the high-speed line operating at a baud rate of 1200 baud was usually slower than the microprocessor and all its peripherals, there was one circumstance when the LINK program could not keep pace with the line. If the



printer option were on and a line feed character were being implemented, a delay resulted while waiting for the printer to get ready for the next character. To provide for this circumstance, all data received from the IBM 360 was routed through a First-In-First-Out (FIFO) buffer. After determining that the USART receive buffer did not have a byte ready, the CPU next checked both the CRT and printer to determine if they were ready to receive a byte. If so, the last byte received was output. If either the CRT or printer were not ready, the byte was stored in the FIFO buffer and the USART receive buffer rechecked. In practice the buffer usually expanded after encountering a line feed character because of the printer delay, but caught up before the end of the next line due to the superior baud rates of the CRT (2400) and the printer (9600).

Another type of buffer was utilized in the transmit file and receive file subprograms. A file to be transmitted to the IBM 360 was first completely loaded into memory before transmission, similar to the operation of the PRINT program. If the file size exceeded the available memory, then part of the file was loaded and transmitted, and then another part until the end of the file was encountered. For the 48K system the memory available as a data buffer was about 38K. For files being received from the IBM 360, an insurmountable problem sometimes arose. The file was being received too fast to simultaneously write on the diskette,

so the data had to be buffered. If the file exceeded the available memory, then transmission by the IBM 360 had to be stopped immediately to avoid losing any of the file. Because of the timesharing operation of the IBM 360 under CMS, the transmission could not be immediately interrupted. Since this anomaly could not be corrected, it was determined that the user would have to limit incoming files to 38K or else break up larger files into 38K segments.

#### 4. LINK User's Guide

Precise instructions for the operation of the LINK program are contained in the LINK User's Guide, Appendix C. The assembly program listing is included as Appendix G.

#### C. GO Program

The GO program controls the operation of the ST-800 Analog to Digital Converter with the Direct Memory Access Controller. The primary concern in designing this system was to effect the fastest possible data sampling rate while maintaining a high degree of flexibility. The crucial element of speed and the complexity of the component interaction combined to make the software development for this system quite a challenge.

When operating with the DMA, the ST-800 does not communicate directly with the CPU. The DMA is programmed with the total number of converted data bytes to be passed and the memory address at which to store the first byte. The ST-800 is programmed through the DMA with regard to the initial and final channels to be converted. The process of converting the analog signal inputs for the initial through final channels and passing them to the DMA is known as a scan. ~~Full handshaking between the DMA and ST-800 circuits~~ is employed and the throughput time for converting an analog signal into two hex bytes and passing both bytes through the DMA to random access memory is approximately twenty-two microseconds. When one scan is completed, the ST-800 relies on either the CPU or a signal from the scan clock to initiate another scan. When the word length register in the DMA counts down to zero, the DMA has finished its programmed task and waits to be reset.

Initially the approach toward meeting the primary goal was to set up the system on a dual-interrupt basis. Although this scheme provided tremendous flexibility, in some cases it retarded the conversion process from full speed operation. Another configuration was ultimately adopted, but the dual-interrupt approach had some merit and is discussed under the heading of Alternative Solutions.

The Scan-clock Option on the ST-800 provides for initiation of subsequent scans after the first is completed. An end-of-scan signal starts a preset countdown clock which, when timed out, initiates the next scan. The disadvantages to this option were that hardware changes were required to vary the countdown interval, and the fastest scan repetition rate was 1000 scans per second.

By enabling the Scan-clock Option but disabling the countdown timer itself, an external pulse could be applied to initiate scans through the scan-clock circuitry. This method was adopted as the most flexible as well as the fastest.

#### 1. Data File Parameters

The contents of a data file is a collection of hex digits and two such files would be indistinguishable without additional information. The first file of data was named DATA01.XXX and subsequent filenames were incremented by one digit. Through a sequence of user prompts and responses, the program determined which options the user desired. This information was used to set up the data conversion run and also was recorded in the data file to facilitate later identification. Included in the file information block were the initial and final channels, number of data points in the sample, scan repetition rate, run coordination number, and

the number of data bytes involved in each scan.

## 2. ST-800 and DMA Setup

The number of data points specified by the user was multiplied by two since each digitized data word required two bytes of storage. The result was programmed into the word length register of the DMA. The initial and final channels to be scanned were loaded into the ST-800 via the DMA. The memory location 900H was programmed into the DMA as the future address of the first converted data byte. The DMA controller was then commanded to transfer data from the ST-800 to memory. The ST-800 was commanded by the CPU to start conversion.

## 3. DMA Reset

Since the pulse generator which initiated subsequent scans was disabled at this point in time, the ST-800 converted through one complete scan and stopped. The word length register on the DMA was not decremented to zero after one scan, hence no interrupt was forthcoming. This first dummy scan was necessary simply to synchronize the ST-800 with the pulse generator.

The word length register and memory address register were now reloaded with their initial values. The DMA was



given a new command word which allowed it complete control of the data bus and the user prompted to enable the pulse generator. By this method the first data byte from the first channel went into the first memory location. The channels were converted at the maximum throughput rate of the ST-800-DMA combination (about 45,000 Hertz) until each scan was completed, and the scan repetition rate coincided with the pulse generator output. When the entire data sample was finished, the word length register decremented to zero and the DMA issued a level four interrupt. A jump vector which had been previously inserted into the RST 04 location directed program control to a routine which serviced the interrupt, disabled the DMA, and prompted the user to disable the pulse generator. Lastly the program wrote the data file to the system diskette if desired by the user and then set up for another run.

#### 4. GO User's Guide

The GO User's Guide, Appendix B, provides the details for setup and operation of the data acquisition system. The GO Assembly program is listed in Appendix F.

#### D. DATLINK Program

The DATLINK program is a modification of LINK and is identical in most respects. Since the data acquired with

the GO system was recorded on the diskette in hex bytes, each byte had to be converted into two ASCII characters before transmission over the high-speed line. The transmit file mode of DATLINK limited each line to the number of data bytes obtained from each scan. Therefore files created under CMS on the IBM 360 were already formatted with one scan per line.

Because of the additional code needed to accommodate the data files, the receive file mode was removed from the DATLINK program. The User's Guide for DATLINK is included as Appendix D and the Assembly program listing is Appendix H.

#### IV. SYSTEM QUALIFICATION

System qualification was achieved by digitizing known analog signals, storing the data files on diskette, and transmitting the files to the IBM 360 for data reduction. The output files were then transmitted back to the micro-computer system, stored on diskette, and output to the line printer.

##### A. Shannon's Sampling Theorem

When digitizing a signal, care must be taken to ensure that Shannon's Sampling Theorem is obeyed; otherwise there is a possibility of aliasing occurring. In general, a degree of conservatism should be followed when digitizing such that ten to fifteen samplings should take place each fundamental period and at least ten to fifteen waveforms should be recorded. If the presence of higher harmonics were suspected, added conservatism should be used.

##### B. Qualification Test

Sinusoid waveforms with carefully measured frequencies of 20, 200, and 1000 Hertz were chosen for data sampling. The system was set up according to the GO User's Guide,

Appendix B, and the scan triggering pulse generator frequency was measured at 300, 3000, and 10,000 Hertz, respectively. After the data was acquired and stored, the files were sent via the DATLINK program to the IBM 360. Next, using the LINK program, a FORTRAN reduction program was created within the IBM computer similar to the BASIC program reported by Pickelsimer, Ref. 13, and Englehardt, Ref. 1.

### C. Data Sampling Theory

One common form of unsteady data recording involves periodic natural signals of arbitrary waveform having a well-established fundamental frequency. As an example, instrumentation transducer system transfer functions would involve data records at various prescribed frequencies of input and output signals. The systems described in this thesis are naturally oriented for providing transfer function type of information using the following cross-correlation scheme to pick out the Fourier components of a deterministic type waveform. Consider a data set  $X(1)$ ,  $X(2)$ ,  $X(3)$ , ...,  $X(N)$  representing a waveform of a known frequency which has been sampled at given intervals. After truncating the set to an integral number of periods, the bias or average value can be determined and removed from each member of the set.

#### D. Fourier Analysis\

Any periodic waveform can be represented by the Fourier Series

$$X(t) = \sum_{n=1}^{\infty} [A_n \cos n\omega_1 t + B_n \sin n\omega_1 t + A_0]$$

and the coefficients can be found by

$$A_0 = 1/T \int_0^T X(t) dt$$

$$A_n = 2/T \int_0^T X(t) \cos n\omega_1 t dt$$

$$B_n = 2/T \int_0^T X(t) \sin n\omega_1 t dt$$

In cases where the data set represents a known simple waveform (no harmonics) such as the sinusoid used in the system qualification, the Fourier coefficients can be obtained by an estimation procedure. For the assumed truncated data set with bias removed

$$Y(1), Y(2), Y(3), \dots, Y(M)$$

representing a discretized sinusoid signal with frequency  $F$  and scan rate of  $\Delta T$ , the first harmonic estimates become

$$A = (2/M) \sum_{I=1}^M Y(I) \cos [2 \text{ Pi } F \Delta T (I)]$$

$$B = (2/M) \sum_{I=1}^M Y(I) \sin [2 \text{ Pi } F \Delta T (I)]$$

and the magnitude and phase are estimated by



$$C = [ A^2 + B^2 ]^{1/2}$$

$$\phi = \text{Tangent Inverse } [ -B/A ]$$

Higher harmonics, such as the Kth, can be estimated by replacing  $[2 \text{ Pi } F \Delta T (I)]$  with  $[2 \text{ Pi } (K) F \Delta T (I)]$  in the above equations.

Had the data set  $X(1), \dots, X(N)$  resulted from a random waveform, the above formulae conceptually would be replaced by applying a Fast Fourier Transform algorithm to the data set. This procedure is built into several existing programs in the Computer Center library.

#### E. Interchannel Sampling Delay

The Fourier Coefficient estimation procedure described above was used during system qualification to establish the interchannel sampling delay. The scan rate or sampling rate refers to the time involved between converting the (Ith) and (Ith + 1) samples of a specific input channel. This scan rate is adjustable since it is controlled by an external pulse generator serving as a trigger. Whenever more than one channel is being digitized, there is a slight time difference between the instants of sampling for the respective channels. This time difference is known as the interchannel sampling delay and is not adjustable since it is established

by the throughput rate of the Analog to Digital converter-DMA controller combination.

#### F. REDUCE Fourier Coefficient Program

The FORTRAN program created to reduce the system qualification data was similar to the BASIC program used by Englehardt in Ref. 1. Since the test signals were simple waveforms with known frequencies, the estimation procedure described above was used. The REDUCE Fortran Program, listed as Appendix M, was written to accommodate data from four input signals. Since the same test signal was applied to each of the four input channels, the phase differences evident in the reduced data sets gave a close determination of the interchannel sampling delay (21.7 microseconds).

#### G. System Qualification Results

The reduced data from the three test runs are presented in Appendix N. The sinusoid waveforms had identical magnitudes and that fact was reflected on all four channels of data for each of the three test runs. The magnitudes of the second harmonics were approximately 0.3 percent of the first harmonic magnitude in each case. The existence of a second harmonic was attributable to slight imperfections in the sinusoid generator used for the test waveforms.

The most significant finding from the reduced data was the interchannel sampling delay. For each test run, the difference in phase between two consecutive channels, when divided by the period of the test waveform, indicated a delay of approximately 21.7 microseconds. The throughput rate for the combination of Analog-to-Digital converter and DMA controller was faster than had been predicted. Therefore the maximum sampling rate of the data acquisition system was determined to be slightly in excess of 45,000 Hertz, as compared to the initial value of 40,000 Hertz estimated.

## V. ALTERNATIVE SOLUTIONS

The existence of multiple solutions to a specific problem leads to a variety of approaches in microcomputer application. Hardware selection between commercially manufactured or user-constructed devices, the choice of hardware or software to accomplish a given task, and the infinite approaches of software itself exemplify some of the decisions facing the potential user.

Initially a circuit board was constructed for the purpose of driving the Model 40 Printer and high-speed line. Many design problems were encountered and valuable experience was gained. However, the Intel SBC 534 Input/Output Board was later utilized because of its capacity for future system improvement.

### A. Dual-Interrupt Data Acquisition

The concept first implemented in setting up the Analog to Digital Converter and the Direct Memory Access controller was to use a timer circuit contained on the SBC 534 board to initiate each scan. A jumper selectable option on the SBC 534 permitted the series operation of two timers. One timer served as a clock for the second timer which initiated an

interrupt signal after counting down to zero. The DMA controller and SBC 534 board were hardwired to generate level four and level five interrupts, respectively. The DMA controller and Analog to Digital Converter were programmed for one complete scan followed by an interrupt. The timers and interrupt controller on the SBC 534 board were programmed to delay for a specific interval before interrupting. Starting both processes together, the program waited for the DMA controller interrupt indicating the end of the scan, and then reset the DMA controller. When the timed interrupt occurred, a software routine reset the timers and re-initiated the two circuits. When the desired number of data points had been converted, the program disabled the interrupt mechanism and wrote the data on the system diskette.

While the operational details of the dual-interrupt setup are contained in the G02 program listing, Appendix J, this approach was ultimately replaced by the system already described. Two substantial obstacles to its successful operation were never overcome. The presence of the SBC 534 board installed in the MDS mainframe caused a level five interrupt during the bootstrap operation resulting in an aborted disk drive interface. A patch inserted into the CP/M BIOS program averted the untimely interrupts, but a more significant problem remained.



The interrupt service routines were long and cumbersome, particularly the routine that reset the SBC 534 timers. In order to effect the exact desired interval between scans, the time required to implement the reset instructions was taken into account by modifying the countdown interval to a value of 100 microseconds less than the scan interval. This difference was estimated by totalling the instruction cycle times in the routine. Also, the DMA interrupt service routine had to be completed before the timer interrupt occurred so as to avoid stacked interrupts. As shown in Fig. 3, the allowable conversion time of approximately twenty-two microseconds per channel ( 1 - 2 ) was 150 microseconds less than the scan period.

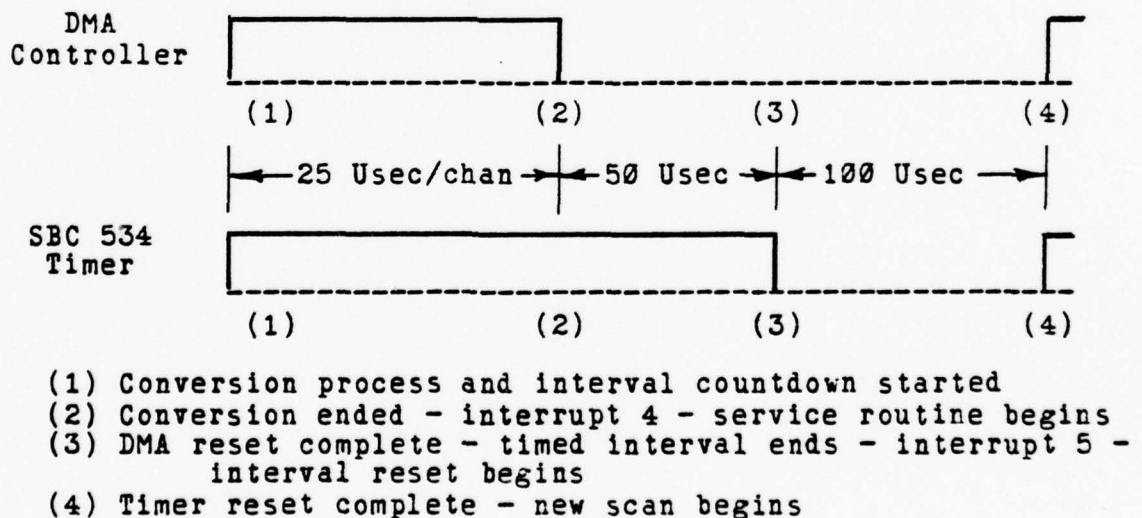


Figure 3 - Dual Interrupt Timing

These software delays resulted in a considerable limitation on the maximum scan rates. With the dual-interrupt process,

the eight channel scan rate was only 2800 Hertz and the one channel rate was 5000 Hertz. With the externally timed system described earlier, the eight channel and one channel scan rates were 5000 Hertz and 45,000 Hertz, respectively.

#### B. Model 40 Printer as a List Device

The CP/M system provides for the operation of a "list" device which originally was designated as the teletype terminal. Several routines within the BIOS program and the MDS monitor divert the microprocessor output to the list device. For example, the CP/M routines TYPE and PIP, as well as the monitor function LO (for List Out), are directed to the list facility. Additionally, by depressing a Control P key, the user can cause all characters directed to the console to also be echoed to the list device. Before the printer can be used as the CP/M list device, it must be initialized by a separate routine such as the ON Assembly program which is included as Appendix L, and the CP/M itself must be altered to address the printer.

A simple patch to the CP/M BIOS program, included as Appendix K, can be used to alter the system so that output to the list device can be redirected to the Model 40 Printer. If the printer USART were programmed beforehand to accept data, the patched CP/M could produce a printed copy of all the information presented on the console. The patch

may be implemented under DDT control and the patched file  
can be used to generate a patched system disk.

## VI. CONCLUSIONS

The data acquisition system developed during this project provided an extremely flexible, dynamic tool for investigating rapidly changing experimental aerodynamic phenomena. Signals from analog measuring devices were sampled at a maximum rate of 45,000 times per second and the data stored on magnetic disks. The data was then expeditiously transferred to the IBM 360 computer where higher level language programs directed the efficient reduction of raw data to formatted answers. The empirical results were then returned to local microprocessor environment and printed. The printer was operated alone to produce hard copy source listings, records of microprocessor functions, and text formatted printouts such as this document.

### A. Future System Improvements

The speed at which data files were transmitted to the IBM 360 computer was limited by the IBM 2701 Data Adapter unit to 1200 baud or about 120 characters per second. Although the rate increase over earlier interfaces was by a factor of eleven to one, the capability exists to further improve the speed another eight times to a rate of 9600 bits per second. The MDS system including hardware and software

was designed to run at the higher speed and only minimal software changes would be necessary to effect such an improvement. Because other users cannot accommodate the 9600 baud, the IBM 2701 unit is hardwired to operate at only 1200 baud.

The scheduled expansion of the IBM interface for high speed line operation will provide a line hardwired to operate at 4800 baud. Whenever the IBM facilities are modified, the microprocessor can be upgraded by making some minor changes to the LINK and DATLINK programs. The countdown number applied to the high-speed line USART should be altered in both programs to generate the faster baud rate. Also, during operation under the receive file mode of the LINK program, a subroutine "CONCUT" echoes all received characters to the CRT terminal. Since the CRT baud rate of 2400 baud is less than 4800, the instruction "CALL CONOUT" (08B8H) should be deleted.



## APPENDIX A

### Glossary

ASCII: American Standard Code for Information Interchange. This is a seven-bit-plus-parity code established by the American National Standards Institute to achieve compatibility between data services.

assembler: a compiler that translates assembly language into hex code and assigns memory locations to labels.

assembly language: programming language used in microcomputer applications.

baud: a serial data transmission rate expressed in bits per second.

BIOS: Basic Input/Output Operating System - a subprogram of the CP/M system that effects all transfers of information between the CPU and its peripheral devices.

bit: binary digit - a single unit of information in a binary word.

buffer: a block of random access memory that has been reserved for temporary data storage.

byte: an eight-bit binary word which is processed as a single quantity.

CMS: Cambridge Monitoring System - a time sharing scheme used by the IBM 360 computer which allows several users simultaneous access to a single virtual machine.

CRT: cathode ray tube - a television-like picture tube used in visual display terminals.

CP/M: Control Program/Monitor - a software system which allows the microprocessor to be operated as a microcomputer. The system is described in Ref. 10.

CPU: Central Processor Unit - the area of the microcomputer

that computes and controls all logical and arithmetic functions.

DMA: Direct Memory Access - a facility whereby input/output data can be transferred to/from memory without passing through the CPU.

FIFO: First-In-First-Out - a buffer in which data is inserted and removed in the same order.

hardware: the physical circuitry and related devices within the microprocessor.

Hertz: units of rate of repetition (cycles per second).

hex: number system based on 16 decimal - one hex digit equates to four binary bits; e.g., 14 decimal is E hex or 1110 binary.

instruction cycle: a finite time span during which the CPU executes programmed instructions. For the MDS this time span can be as short as 2 microseconds. The instruction cycle time may be computed by multiplying the number of clock cycles in a given instruction by 0.5 microseconds.

interrupt: an independent circuit and logic system within the microcomputer. Certain peripheral devices can signal the interrupt logic controller which screens interrupt priorities so that several simultaneous signals can be processed. The interrupt controller halts program execution and diverts the CPU's attention to a subroutine that services the interrupt.

K: symbol used to denote one kilo-byte (1024 decimal or 400 hex bytes) of memory.

machine code: the bit patterns actually used by the CPU to execute its assigned logic functions.

MDS: Microcomputer Development System - the Central Processor Unit with related memory and peripheral devices.

peripheral device: any major independent component controlled by the CPU; e.g., the CRT, teletype, printer, disk drive, or Analog to Digital Converter.

PL/M: Programming Language/Medium.

RAM: random access memory - volatile memory area used for program code and data storage.

RS-232C driver: a transistorized switching device which converts TTL voltage levels to +/- 15 volts for longer range transmission. The RS-232C refers to an Electronic Industries Association (EIA) specification for the device.

ROM: Read Only Memory - non-volatile memory in a computer which contains permanent machine code.

software: the program which contains routines to operate the microcomputer.

throughput: refers to the elapsed time for one complete cycle; e.g., the Analog to Digital Converter throughput includes the time to sample and convert an input, pass the digitized word to the DMA, and set up for the next cycle.

TTL: Transistor Transistor Logic - low current logic devices operate with five volts D. C. power supplies. Subsequently a logical true state is indicated by +5 volts and a false state by 0 volts.

Usec: microsecond - one millionth of a second.

USART: Universal Synchronous Asynchronous Receiver Transmitter - integrated circuit device which converts parallel transmissions into serial transmissions and vice versa.

XON: an ASCII "11" which signifies the beginning of a transmission.

XOFF: an ASCII "13" which signifies the end of a transmission.

## APPENDIX B

### GO USER'S GUIDE

#### I. CAPABILITIES

A. GO INTERFACES THE INTEL MDS 800 MICROPROCESSOR AND DIRECT MEMORY ACCESS CONTROLLER BOARD WITH THE DATEL ST-800 ANALOG TO DIGITAL CONVERTER BOARD FOR HIGH SPEED DATA ACQUISITION. A MAXIMUM OF 16 CHANNELS OF ANALOG DATA CAN BE INPUT, CONVERTED, AND STORED IN RANDOM ACCESS MEMORY AT A RATE OF 45 KHZ.

B. GO INTERFACES A SEQUENCE OF PROMPTS AND USER RESPONSES. THESE RESPONSES ARE USED BY THE PROGRAM TO SET UP THE ANALOG TO DIGITAL CONVERTER AND DIRECT MEMORY ACCESS CONTROLLER TO PROVIDE A LEVEL FOUR INTERRUPT WHEN DATA HAS BEEN ACQUIRED.

C. GO WRITES EACH BLOCK OF ACQUIRED DATA ONTO A FLOPPY DISK FOR LATER RETRIEVAL. EACH DATA FILE CONTAINS FORMATTED PARAMETERS WHICH DESCRIBE THE DATA SAMPLING PROCEDURES, SUCH AS NUMBER OF DATA POINTS, SCAN RATE, AND A RUN COORDINATION NUMBER WHICH IS ENTERED BY THE USER.

D. A VARIABLE FREQUENCY PULSE GENERATOR IS USED DURING THE DATA ACQUISITION PROCESS TO INITIATE EACH SCAN. CARE MUST BE TAKEN TO AVOID SELECTING A SCAN RATE WHICH EXCEEDS THE SYSTEMS CAPABILITY. FIGURING A THROUGHPUT TIME OF TWENTY-TWO MICROSECONDS PER CHANNEL FOR CONVERSION TO MEMORY STORAGE, THE SELECTED PULSE RATE SHOULD NOT EXCEED 45,000 DIVIDED BY THE NUMBER OF CHANNELS; E.G., IF EIGHT CHANNELS WERE TO BE SAMPLED, THE SCAN RATE SHOULD NOT EXCEED 5500 SCANS PER SECOND.

E. SUCCESSIVE DATA SAMPLING RUNS ARE RECORDED ON THE FLOPPY DISK IN DRIVE B WITH FILENAMES DATA01.XXX, DATA02.XXX, ETC. IF A LIKE FILENAME ALREADY EXISTS ON THE DISK, IT IS DELETED BEFORE THE NEW FILE IS WRITTEN.

#### II. SETUP

A. ANALOG INPUTS ARE LIMITED TO PLUS OR MINUS FIVE VOLTS AND SHOULD BE CONNECTED TO THE SYSTEM THROUGH A LOCALLY CONSTRUCTED INPUT TERMINAL. THE ANALOG TO DIGITAL CONVERTER CAN THEN BE CALIBRATED BY EXECUTING A DATEL TEST PROGRAM ST-800 (AVAILABLE ON DISK AND PAPER



TAPE IN THE MICROPROCESSOR LAB).

B. A NEGATIVE TTL PULSE (WHICH STROBES ZERO VOLTS) IS ALSO CONNECTED TO THE INPUT TERMINAL. A DIGITAL FREQUENCY COUNTER SHOULD BE INTERCONNECTED TO OBTAIN PRECISE SCAN RATE INFORMATION. THE PULSE GENERATOR SHOULD BE TESTED AND THEN PLACED IN A STANDBY CONDITION (NO PULSING).

C. A PREFERABLY BLANK, FORMATTED DISKETTE SHOULD BE PLACED IN DISK DRIVE B.

### III. OPERATION

THE GO PROGRAM IS EXECUTED BY THE FOLLOWING COMMAND:

GO <CARRIAGE RETURN>

IMMEDIATELY THE USER IS PROMPTED WITH

ENTER STARTING CHANNEL

FOLLOWING USER'S REPLY, THE NEXT PROMPT APPEARS:

ENTER FINAL CHANNEL

NOTE: RESPONSE TO THE ABOVE TWO PROMPTS SHOULD BE IN THE RANGE OF 0 - 15. IF THIS RANGE IS EXCEEDED OR IF THE STARTING CHANNEL IS GREATER THAN THE FINAL CHANNEL, ANOTHER PROMPT APPEARS:

TRY AGAIN, TURKEY

AND THE ABOVE PROMPTS ARE REPEATED.

NEXT THE USER IS PROMPTED WITH A CHOICE OF DATA BLOCK SIZES:

ENTER DESIRED NUMBER OF DATA POINTS

ENTER	DATA POINTS	DISK SPACE
A	1024	2K
B	4096	8K
C	10240	20K
D	20480	40K
E	26624	52K(62K SYSTEM)

THE USER SELECTS ONE OF THE OPTIONS BY TYPING THE APPROPRIATE LETTER AND A CARRIAGE RETURN.

USER IS THEN PROMPTED WITH

ENTER SCAN RATE



THIS RESPONSE CAN BE ENTERED IN ANY FORMAT

NOTE: THE ACTUAL SCAN RATE IS DETERMINED BY THE PULSE GENERATOR. THE RESPONSE TO THE ABOVE PROMPT WILL APPEAR IN THE FILE INFORMATION PARAMETERS.

THE NEXT PROMPT IS

ENTER COORDINATION NUMBER

THIS RESPONSE CAN BE ANYTHING THE USER MIGHT CHOOSE TO DISCRIMINATE BETWEEN VARIOUS RUNS.

FINALLY THE SYSTEM INDICATES A READY CONDITION BY

START PULSE GENERATOR

AT THIS TIME OR WHENEVER USER CHOOSES, THE PULSE GENERATOR SHOULD BE CHANGED FROM A STANDBY TO PULSING CONDITION. THE COMPLETION OF A RUN IS SIGNALLED BY A BEEP AND

RUN COMPLETE - DISABLE PULSE

THE PULSE GENERATOR SHOULD BE RETURNED TO A STANDBY CONDITION AT THIS TIME. THE USER IS PROMPTED WITH

WRITE DATA FILE ON DISK?? (Y/N)

IF USER SELECTS ANY KEY BUT "N", THE PROGRAM WILL ECHO THE FILE PARAMETERS TO THE CONSOLE FOR USER VERIFICATION AND WRITE THE DATA FILE ONTO THE DISKETTE IN DRIVE B. ANY PROBLEM INCURRED IN THE WRITE PROCESS WILL BE DETAILED BY EITHER

DISK WRITE ERROR - TRY ANOTHER

OR

DISK FULL

AFTER PLACING A CLEAN DISK IN DRIVE B, USER SHOULD TYPE A CARRIAGE RETURN TO START THE WRITE PROCESS AGAIN.

NOTE: REGARDLESS WHETHER THE DATA ACQUIRED IN A RUN IS WRITTEN ON A DISK, THE DATA FILENAME WILL BE INCREMENTED.

THE NEXT PROMPT TO APPEAR IS

ANOTHER DATA RUN DESIRED?? (Y/N)

SELECTION OF Y WILL START THE PROMPTS AGAIN, AND SELECTION OF ANY OTHER KEY WILL REBOOT THE SYSTEM AND

RETURN USER TO CPM.

NOTE: IF THE PROGRAM IS NOW RE-EXECUTED, THE DATA  
FILENAME COUNT WILL START OVER AT DATA01.XXX AND  
OVERWRITE PREVIOUS DATA FILES.

#### IV. DATA FILES

AN ACQUIRED DATA FILE CAN BE DUMPED UNDER CP/M. THE  
FIRST 128 BYTE BLOCK OF THE FILE CONTAINS INFORMATION  
RELATING TO ITS ACQUISITION. A SAMPLE DUMPED FILE  
FOLLOWS:

```
44 41 54 41 30 31 01 07 31 30 32 34 24 35 30 30
30 24 30 30 39 31 31 30 30 33 24 00 00 00 00 00
12 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
10 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 ETC
```

THE FIRST SIX BYTES ARE THE FILENAME IN ASCII  
DATA01

THE NEXT TWO BYTES ARE THE INITIAL AND FINAL CHANNELS  
IN HEX

01,07

THE NEXT THREE PARAMETERS ARE ASCII CODE INDICATING THE  
NUMBER OF DATA POINTS, SCAN RATE, AND RUN COORDINATION  
NUMBER, EACH FOLLOWED BY THE DELIMITER "\$"

1024

5000

00911003

THE '12' INDICATES THAT 1200H WAS THE UPPER LIMIT ON  
MEMORY USED -

THE '10' IS THE HEX REPRESENTATION OF THE NUMBER OF  
MEMORY BYTES PER SCAN

THE REMAINDER OF THE BLOCK IS ZEROES

M. T. ELLIOTT, NPGS  
AUGUST 28, 1978

## APPENDIX C

### LINK USERS GUIDE

I. LINK INTERFACES THE MDS 800 (AND MODEL 40 PRINTER) WITH CP/CMS THROUGH A 1200 BAUD TELEPHONE LINE. BOTH THE LINE AND THE PRINTER ARE DRIVEN BY 8251 USARTS INCORPORATED IN AN SBC534 I/O BOARD. LINK OPERATES IN ONE OF THREE MODES AS FOLLOWS:

#### A. DIRECT LINKUP MODE

1. TRANSMITS CHARACTERS TYPED ON KEYBOARD TO CP/CMS WITH SOME FILTERING BUT NO BUFFERING; ECHOES CHARACTERS TO CONSOLE (AND PRINTER)
2. RECEIVES CHARACTERS FROM CP/CMS AND UTILIZES A FIFO BUFFER TO PRINT THE CHARACTERS ON THE CONSOLE (AND PRINTER)
3. ALTHOUGH NO HANDSHAKING IS UTILIZED ON THE LINE, SOFTWARE PROVISIONS ALLOW EITHER END TO INTERRUPT THE OTHER'S TRANSMISSIONS
4. CERTAIN CHARACTERS TYPED ON THE KEYBOARD ARE FILTERED OUT:

RUBOUT - BACKSPACES THE CONSOLE AND TRANSMITS A DELETE CHARACTER SYMBOL "@"

CONTROL I - ECHOES AND TRANSMITS A "?" TO INDICATE A LOGICAL TAB - NOTE: "?" MUST BE PREVIOUSLY DEFINED TO THE CMS AS A TAB CHARACTER

CONTROL U - TRANSMITS A DELETE LINE SYMBOL "["

CARRIAGE  
RETURN - TRANSMITS END OF LINE SYMBOL AND WAITS FOR AN ANSWER

ADDITIONAL CONTROL CHARACTERS ALTER PROGRAM EXECUTION AS FOLLOWS:

CONTROL C - REBOOTS SYSTEM

CONTROL D - RETURNS USER TO DIRECT LINKUP  
MODE

CONTROL P - TURNS PRINTER ON IF OFF AND VICE  
VERSA

CONTROL R - INITIALIZES "RECEIVE FILE" MODE

CONTROL T - INITIALIZES "TRANSMIT FILE" MODE

#### B. TRANSMIT FILE MODE

1. AUTOMATICALLY ISSUES ALL CP/CMS COMMANDS TO EFFECT THE TRANSFER OF AN ENTIRE FILE FROM FLOPPY DISK TO CP/CMS P-DISK
2. LINEFEED CHARACTERS APPEARING IN THE FLOPPY DISK FILES ARE FILTERED OUT; HOWEVER, TAB CHARACTERS ARE CONVERTED TO "?" AND TRANSMITTED TO CP/CMS
3. THE PRINTER DOES NOT WORK IN THIS MODE

NOTE: WHEN TRANSMITTING CONTINUOUS DATA FILES, THE PROGRAM SETS THE LINE LENGTH AT 132 CHARACTERS (83H). THE NAMED CMS FILETYPE MUST ACCOMMODATE THIS RECORD LENGTH. IF A SHORTER LINE LENGTH IS DESIRED, THE PROGRAM CAN BE ALTERED UNDER DDT AT PROGRAM COUNT OF 984H.

#### C. RECEIVE FILE MODE

1. AUTOMATICALLY ISSUES ALL CP/CMS COMMANDS TO EFFECT THE TRANSFER OF AN ENTIRE P-DISK FILE TO THE FLOPPY DISK
2. THE DATA BEING RECEIVED IS ECHOED TO THE CONSOLE FOR THE CONVENIENCE OF THE USER
3. THE TRANSMISSION BY CP/CMS CAN BE INTERRUPTED BY DEPRESSING ANY KEY. THIS ACTION RESTORES USER TO THE "DIRECT LINKUP" MODE AND THE CMS IS SHIFTED INTO CP. THE TERMINATED FILE IS LOST ALTHOUGH THE FILE-NAME WILL EXIST IN THE DISK DIRECTORY.

## II. OPERATION

#### A. DIRECT LINKUP MODE

THE PROGRAM IS EXECUTED AS FOLLOWS:

LINK <CR>

THE USER IS PROMPTED WITH

DIAL 2721 FOR LINE -- TYPE CARRIAGE RETURN

A CONNECTED LINE IS INDICATED BY THE MESSAGE

CP-67 ON LINE

NORMAL LOGIN PROCEDURE AND CP/CMS TYPING CONVENTIONS ARE USED AND ANY KEY WILL "BREAK" THE CMS TRANSMISSIONS

B. TRANSMIT FILE MODE

UPON INITIALIZATION BY CONTROL T, USER IS PROMPTED WITH

DISK:FILENAME.FILETYPE

THE FILE TO BE TRANSMITTED SHOULD BE ENTERED EXACTLY ACCORDING TO THIS FORMAT. IF FORMAT IS VIOLATED, THE USER IS PROMPTED WITH

REPEAT

IF THE NAMED FILE CANNOT BE FOUND AS LISTED, THE APPROPRIATE PROMPT APPEARS

FILE NOT FOUND

AND USER IS RETURNED TO THE "DIRECT LINKUP" MODE. ASSUMING PROPER ENTRY OF THE FILE TO BE TRANSMITTED, THE NEXT PROMPT IS

CMS FILENAME FILETYPE?

THE FORMAT OF THE ANSWER TO THIS PROMPT IS NOT SPECIFIED BUT NOTE THAT THE CMS FILENAME WILL BE EXACTLY AS ENTERED.

NOTE: IF A KNOWN MISTAKE IS MADE IN ANSWERING THE ABOVE PROMPTS, TYPING CONTROL U WILL ALLOW USER TO START THE LINE AGAIN.

NOTE: THE CMS FILENAME SHOULD BE A NEW FILE SO THE CMS WILL SHIFT DIRECTLY INTO "INPUT" MODE.

AFTER ENTERING THE FILENAMES, THE PROGRAM OPERATES AUTOMATICALLY BUT ECHOES ITS COMMANDS TO CMS ON THE CONSOLE SO THE USER IS AWARE OF THE PROGRAM STATUS

NOTE: TYPING CONTROL D WILL IMMEDIATELY RETURN USER TO THE "DIRECT LINKUP" MODE



----- SAMPLE TRANSMITTED FILE -----

```
LINK:  DISK:FILENAME.FILETYPE
USER:  A:LINK.ASM<CR>
LINK:  CMS FILENAME FILETYPE?
USER:  HOOKER FORTRAN<CR>
LINK:  EDIT HOOKER FORTRAN
CMS:   >EDIT HOOKER FORTRAN
      >NEW FILE
      >INPUT:
LINK:  >TRANSMITTING
CMS:   >EDIT
LINK:  >SAVE
CMS:   >INPUT:
LINK:  >RELOADING
      TRANSMITTING
CMS:   >EDIT
LINK:  >FILE
CMS:   >R;
LINK:  >TRANSMISSION COMPLETE
      0034 RECORDS TRANSMITTED
      >
```

THE USER IS AUTOMATICALLY RETURNED TO THE "DIRECT LINKUP" MODE AT THIS TIME.

NOTE: IF THE FILE TO BE TRANSMITTED EXCEEDS THE BUFFER OF 40K BYTES, THE PROGRAM COMMANDS CMS TO SAVE THAT PORTION OF THE FILE, THEN 40K MORE BYTES ARE READ AND TRANSMITTED.

NOTE: FLOPPY DISK RECORDS ARE 128 BYTES IN LENGTH; P-DISK RECORDS ARE 829 BYTES IN LENGTH. DEPENDING ON THE CMS FILETYPE USED, ONE CMS RECORD EQUALS FROM ONE TO FOUR MDS RECORDS.

C. RECEIVE FILE MODE

UPON INITIALIZATION BY CONTROL R, THE FOLLOWING PROMPT APPEARS:

CMS FILENAME FILETYPE?

FORMAT REQUIREMENTS ARE SIMILAR TO THOSE ABOVE FOR "TRANSMIT FILE MODE". THE NEXT PROMPT IS

DISK:FILENAME.FILETYPE

AND AGAIN THE FORMAT IS THE SAME.

NOTE: THE FLOPPY DISK FILENAME AND FILETYPE SHOULD BE NEW TO THE DISK. THE PROGRAM WILL DELETE ANY EXISTING FILE WITH THE SPECIFIED FILENAME AND FILETYPE!!!!

IF DISK SPACE IS LIMITED, ONE OF THESE PROMPTS WILL  
APPEAR:

NO DIRECTORY SPACE AVAILABLE

(APPEARS BEFORE FILE IS TRANSMITTED BY CMS)

OR

DISK FULL

(APPEARS AFTER FILE HAS BEEN TRANSMITTED AND INDICATES FILE LENGTH EXCEEDED THE AVAILABLE DISK SPACE)

IN BOTH CASES, USER IS RETURNED TO THE "DIRECT  
LINKUP" MODE.

NOTE: TYPING CONTROL D WILL IMMEDIATELY RETURN USER  
TO THE "DIRECT LINKUP" MODE

ASSUMING NO DISK PROBLEMS, THE PROGRAM OPERATES  
AUTOMATICALLY.

----- SAMPLE RECEIVED FILE -----

```
LINK:  CMS FILENAME FILETYPE?
USER:  FOURPLAY OUTPUT72<CR>
LINK:  DISK:FILENAME.FILETYPE
USER:  HOWCUM.HEX<CR>
LINK:  PRINT FOURPLAY OUTPUT72
      RECEIVING
CMS:   :54424A2031303948534B37363231304D5F
      :ETC ETC ETC
      :ETC ETC
      :ETC
      >R;
LINK:  >TRANSMISSION COMPLETE
      0078 RECORDS TRANSMITTED
      >
```

THE USER IS AUTOMATICALLY RETURNED TO THE "DIRECT  
LINKUP" MODE.

NOTE: IF THE FILE TO BE RECEIVED FROM CMS EXCEEDS  
THE BUFFER SIZE OF 40K BYTES, THE REMAINDER  
OF THE FILE WILL BE LOST.

NOTE: IF USER ELECTS TO TERMINATE FILE RECEPTION,  
DEPRESSING ANY KEY WILL RETURN PROGRAM CON-  
TROL TO "DIRECT LINKUP" AND THE CMS WILL BE  
INTERRUPTED

A HANDY REFERENCE GOUGE FOR "LINK" FOLLOWS:

LINK

---

<CR>	END OF LINE
RUBOUT	DELETE CHARACTER
CONTROL C	REBOOT
CONTROL D	RETURN TO DIRECT LINKUP
CONTROL I	TAB "?"
CONTROL P	PRINTER ON/OFF
CONTROL R	RECEIVE FILE MODE
CONTROL T	TRANSMIT FILE MODE
CONTROL U	DELETE LINE
BREAK	ANY KEY INTERRUPTS

---

MACK T. ELLIOTT, NPGS  
AUGUST 22, 1978

## APPENDIX D

### DATLINK USERS GUIDE

I. DATLINK IS A MODIFICATION OF THE LINK PROGRAM DESIGNED SPECIFICALLY FOR TRANSFERRING DATA FILES FROM FLOPPY DISK TO CP/CMS P-DISK.

A. DIRECT LINKUP MODE - THIS MODE OPERATES EXACTLY THE SAME AS IN THE LINK PROGRAM

B. TRANSMIT FILE MODE

1. DATA FILES ACQUIRED AND WRITTEN ON THE FLOPPY DISK BY THE GO PROGRAM ARE IN HEX CODE. THE FIRST FILE RECORD (128 BYTES) CONTAINS THE DATA FILENAME, INITIAL AND FINAL CHANNELS OF EACH SCAN, THE SCAN RATE, NUMBER OF DATA POINTS IN THE RUN, AND RUN COORDINATION NUMBER. ADDITIONALLY, THE FIRST FILE RECORD CONTAINS THE MOST SIGNIFICANT BYTE OF THE UPPER LIMIT ON MEMORY SPACE USED, AND THE NUMBER OF MEMORY BYTES USED PER SCAN (NUMBER OF CHANNELS TIMES TWO).

2. THE TRANSMIT FILE MODE ECHOES THE FILE PARAMETERS TO THE CONSOLE AND IMMEDIATELY BEGINS TRANSMISSION OF THE FILE TO CP/CMS. EACH HEX BYTE OF DATA IS CONVERTED TO TWO ASCII CHARACTERS BEFORE TRANSMISSION. THE LINE LENGTH IS SET AT THE NUMBER OF BYTES PER SCAN TO FACILITATE LATER FORMATTING FOR USE IN IBM 360 PROGRAMMING. E.G., THE MAXIMUM LINE LENGTH THAT COULD OCCUR WOULD BE 64 CHARACTERS (16 CHANNELS TIMES TWO BYTES PER CHANNEL TIMES TWO ASCII CHARACTERS PER BYTE).

3. THE MAXIMUM SIZED DATA FILE THAT CAN BE TRANSMITTED IS 40K (52K WITH A 62K SYSTEM) CORRESPONDING TO THE LARGEST DATA SAMPLE THAT CAN BE ACQUIRED WITH THE GO PROGRAM. ALSO, THE NUMBER OF FILE RECORDS TRANSMITTED IS NOT COUNTED AND DISPLAYED WITH THE DATLINK PROGRAM.

C. THE RECEIVE FILE MODE DOES NOT EXIST IN THE DATLINK PROGRAM.

## II. OPERATION

A. DIRECT LINKUP MODE - EXECUTION OF THE DATLINK PROGRAM AND OPERATION OF THE "DIRECT LINKUP" MODE IS EXACTLY THE SAME AS FOR THE LINK PROGRAM.

B. TRANSMIT FILE MODE

UPON INITIALIZATION BY CONTROL T, THE PROMPTS AND REPLIES ARE THE SAME AS FOR THE LINK PROGRAM. BEFORE TRANSMISSION BEGINS, THE USER IS PROMPTED WITH THE DATA FILE PARAMETERS.

----- SAMPLE TRANSMITTED FILE -----

```
DATLINK: DISK:FILENAME.FILETYPE
USER:    B:DATA03.XXX
DATLINK: CMS FILENAME FILETYPE
USER:    FILE FT01F001
DATLINK: DATA03
          1024 DATA POINTS
          5000 SCANS PER SECOND
          RUN COORDINATION NUMBER 822001
          EDIT FILE FT01F001
CMS:     >EDIT FILE FT01F001
          >NEW FILE
          >DEFAULT PARAMETERS SET
          >INPUT
DATLINK: >TRANSMITTING
CMS:     >EDIT
DATLINK: >FILE
CMS:     >R;
DATLINK: >TRANSMISSION COMPLETE
          >
```

C. RECEIVE FILE MODE - UPON INITIALIZATION BY CONTROL R, THE USER IS PROMPTED WITH

TO RECEIVE FILE, USE LINK PROGRAM

THE MESSAGE IS SELF-EXPLANATORY

NOTE: ALL PROMPT REPLY FORMATS, ERROR MESSAGES, AND CONTROL CHARACTER USAGE IS EXACTLY THE SAME AS IN THE LINK PROGRAM.

M. T. ELLIOTT, NPGS  
AUGUST 22, 1978



## APPENDIX E

### PRINT USER'S GUIDE

#### I. CAPABILITIES

A. PRINT INTERFACES THE INTEL MDS 800 WITH THE TELETYPE MODEL 40 HIGH SPEED PRINTER THROUGH AN INTEL SBC 534 INPUT/OUTPUT BOARD. PRINT ACCESSES FILES STORED ON FLOPPY DISK AND TRANSMITS THEM TO THE PRINTER AT A 9600 BAUD RATE.

B. FOR DISK FILES ALREADY FORMATTED, SUCH AS PRN FILES GENERATED BY THE TEX FORMATTER OR THE MACRO ASSEMBLER (PRODUCTS OF DIGITAL RESEARCH), THE PRINT PROGRAM OUTPUTS THE FILE WORD FOR WORD TO THE PRINTER.

C. ALL OTHER FILES STORED ON FLOPPY DISK IN ASCII CODE ARE FORMATTED BY PRINT FOR THE STANDARD 11 X 14 PAPER USED IN THE PRINTER. PRINT PROVIDES FOR ONE INCH MARGINS ON THE BOTTOM AND BOTH SIDES AND A THREE QUARTER INCH MARGIN AT THE TOP. EACH PAGE OF THE PRINTED FILE IS HEADED BY THE FILENAME, FILETYPE, AND PAGE NUMBER. PRINTED FILES ARE NORMALLY SINGLE SPACED, BUT A DOUBLE SPACE OPTION MAY BE SELECTED AND SHOULD COINCIDE WITH THE SPACING SWITCH ON THE PRINTER.

D. FOR PARTIAL PRINTOUTS OF LARGE FILES, THE USER CAN ENTER TWO STRINGS OF UP TO FIFTEEN CHARACTERS EACH, AND THE PROGRAM WILL SEARCH THE FILE AND PRINT ONLY THE TEXT BETWEEN THE STRINGS.

E. THE PRINT PROGRAM LOADS THE ENTIRE FILE INTO RANDOM MEMORY BEFORE COMMENCING OUTPUT TO THE PRINTER. IF THE AVAILABLE MEMORY (40K BYTES) IS EXCEEDED BY THE NAMED FILE, THEN 40K BYTES ARE PRINTED AND THEN ANOTHER 40K BYTES ARE LOADED AND PRINTED.

F. THE PRINT OPERATION CAN BE INTERRUPTED AT ANY TIME BY THE USER.

#### II. OPERATION

THE PRINT PROGRAM IS EXECUTED BY THE FOLLOWING COMMAND:

PRINT <DISK:>FILENAME.FILETYPE

THE PROGRAM TURNS ON THE PRINTER MOTOR AND SEARCHES FOR THE NAMED FILE. IF THE FILE CANNOT BE OPENED AS LISTED, THE FOLLOWING PROMPT APPEARS:

FILE NOT FOUND

DONE

AND THE USER MUST RE-EXECUTE USING THE CORRECT DISK/FILENAME/FILETYPE. AFTER THE FILE IS OPENED, USER IS PROMPTED WITH

TEXT FILE?? (Y/N)

IF THE FILE HAS BEEN GENERATED BY THE TEX FORMATTER OR THE MACRO ASSEMBLER, NO FURTHER FORMATTING BY THE PRINT PROGRAM IS NEEDED. THE USER SHOULD TYPE YES (Y) AND THE FILE WILL PRINT AS FORMATTED. IF NO (N) IS SELECTED, THE NEXT PROMPT IS

TYPE 2 FOR DOUBLE SPACE  
(DEFAULT = SINGLE SPACE)

TYPING ANY KEY OTHER THAN "2" WILL RESULT IN SINGLE SPACING.

NOTE: SELECTION OF DOUBLE SPACING MUST COINCIDE WITH THE SPACING SWITCH SETTING ON THE PRINTER.

NEXT THE USER IS PROMPTED WITH

PRINT ALL (A) OR PART (P)??

IF ANY KEY OTHER THAN "P" IS SELECTED, THE PROGRAM WILL PRINT THE ENTIRE FILE. IF "P" IS SELECTED, ANOTHER PROMPT APPEARS:

ENTER STRING1,STRING2

EITHER STRING MAY BE OMITTED, BUT THE COMMA MUST BE INCLUDED.

NOTE: THE PRINTOUT WILL INCLUDE THE FIRST STRING AND EXCLUDE THE SECOND STRING.

AT ANY TIME THE MODEL 40 IS PRINTING, USER MAY INTERRUPT BY TYPING ANY KEY. THE FOLLOWING PROMPT WILL APPEAR:

TYPE K TO CANCEL OR SPACE TO CONTINUE

THIS MESSAGE IS SELF-EXPLANATORY.

AFTER COMPLETING THE PRINTOUT, THE PRINTER IS TURNED

OFF BY THE PROGRAM. THE FOLLOWING MESSAGE APPEARS ON  
THE CONSOLE:

DONE

A SOFT BOOT BY THE PROGRAM RESTORES USER TO CPM.

NOTE: IF THE PRINTER POWER SWITCH IS OFF OR THE  
PRINTER RUNS OUT OF PAPER, THE PRINT PROGRAM  
IDLES UNTIL THE CONDITION IS RECTIFIED, THEN  
RESUMES PRINTING.

M. T. ELLIOTT, NPGS  
AUGUST 25, 1978

# GO ASSEMBLY PROGRAM

70

```

STKBTM EQU $ ;INITIATE STACK POINTER HERE
;
;
;MESSAGES
;
MSG1: DB CR,LF,LF,'ENTER STARTING CHANNEL $'
MSG2: DB CR,LF,LF,'ENTER FINAL CHANNEL $'
MSG3: DB CR,LF,LF,'START PULSE GENERATOR ----',CR,LF,LF,'$'
MSG4: DB CR,LF,LF,'TRY AGAIN, TURKEY $'
MSG5: DB CR,LF,LF,'DATA POINTS$'
MSG6: DB CR,LF,LF,'ENTER DESIRED NUMBER OF DATA POINTS'
MSG7: DB CR,LF,LF,'ENTER DATA POINTS DISK SPACE'
MSG8: DB CR,LF,LF,'A 2K',CR,LF
MSG9: DB CR,LF,LF,'B 8K',CR,LF
MSG10: DB CR,LF,LF,'C 20K',CR,LF
MSG11: DB CR,LF,LF,'D 40K',CR,LF
MSG12: DB CR,LF,LF,'E 52K (62K SYSTEM)',CR,LF,'$'
MSG13: DB CR,LF,LF,'ENTER'
MSG14: DB CR,LF,LF,'SCAN RATE $'
MSG15: DB CR,LF,LF,'ENTER'
MSG16: DB CR,LF,LF,'COORDINATION NUMBER $'
MSG17: DB CR,LF,LF,'WRITE DATA FILE ON DISK?? (Y/N) $'
MSG18: DB CR,LF,LF,'ANOTHER DATA RUN DESIRED?? (Y/N) $'
MSG19: DB CR,LF,LF,'DISK FULL - TRY ANOTHER - RETURN WHEN READY $'
MSG20: DB CR,LF,LF,'DISK WRITE ERROR - TRY ANOTHER - RETURN WHEN READY $'
MSG21: DB CR,LF,LF,'RUN COMPLETE - DISABLE PULSE',CR,LF,LF,'$'
MSG22: DB
MSG23:
MSG24:
MSG25:

```



0360	314501	LXI	SP,	STKBTM	;SET UP STACK POINTER
0363	3EC3	MVI	A,	JUMP	;JUMP INSTRUCTION
0365	322000	STA	R04		;SET UP INTERRUPT
0368	218104	LXI	H,	RESET4	;ADDR OF INT 4 ROUTINE
036B	222100	SHLD	R04+1		
;CHANGE CPU MASK TO ACCEPT RST 04 INTERRUPTS					
036E	3E6E	MVI	A,	6EH	;ALLOWS RST 0,4,7
0370	D3FC	OUT	MASK		
;SPECIFY DISK DRIVE B FOR ALL DATA WRITES					
0372	0E0E	MVI	C,	14	
0374	1E01	MVI	E,	1	;DRIVE B
0376	CD0500	CALL	BDOS		
;GET VALUES FOR INITIAL AND FINAL CHANNELS AND WORD LENGTH					
SETUP:					
0379	CD4E05	CALL	RECORD		;ZERO OUT RECORD LINE
037C	CD9404	CALL	DIGIT1		;GETS CHANNEL VALUES
037F	218508	LXI	H,	MEMORY+6	;INITIAL CHANNEL VALUE
0382	3A8608	LDA	MEMORY+7		;FINAL CHANNEL VALUE
0385	96	SUB	M		;DETERMINE DIFFERENCE
0386	F28F03	JP	DIFF		
0389	CDFC04	CALL	OOPS		;FINAL CAN'T BE LESS
038C	C37903	JMP	SETUP		;BACKUP AND TRY AGAIN
;DIFF:					
038F	C601	ADI	1H		;NUMBER WORDS PER
0391	17	RAL			;SCAN IS NUMBER OF
0392	32B008	STA	MEMORY+30H		;CHANS TIMES TWO
;DATPT:					

```

; ; DETERMINE NUMBER OF DATA POINTS DESIRED
; ;
0395 11B701      LXI    D,      MSG5      ;PROMPT USER
0398 0E09        MVI    C,      9H
039A CD0500      CALL   BDOS
039D CDF404      CALL   KEY

; ; SEE WHICH CHOICE
; ;
POINT:
03A0 FE41        CPI     'A'
03A2 CABF03      JZ      APOINT
03A5 FE42        CPI     'B'
03A7 CAC703      JZ      BPOINT
03AA FE43        CPI     'C'
03AC CACF03      JZ      CPOINT
03AF FE44        CPI     'D'
03B1 CAD703      JZ      DPOINT
03B4 FE45        CPI     'E'
03B6 CADF03      JZ      EPOINT
03B9 CDFC04      CALL   OOPS
03BC C39503      JMP     DATPT

; ; APOINT:
03BF 010D02      LXI     B,      M5A
03C2 3E08        MVI     A,      9H
03C4 C3E403      JMP     DOWN

; ; BPOINT:
03C7 011C02      LXI     B,      MSB
03CA 3E20        MVI     A,      21H
03CC C3E403      JMP     DOWN

; ; CPOINT:
03CF 012A02      LXI     B,      MSC
03D2 3E50        MVI     A,      51H
03D4 C3E403      JMP     DOWN

;SEE IF A ENTERED
;SEE IF B ENTERED
;SEE IF C ENTERED
;SEE IF D ENTERED
;SEE IF E ENTERED
;NOTHING ELSE IS VALID

```

```

03D7 013902      DPOINT:      LXI      B,      M5D
03DA 3EA0         MVI      A,      0A1H
03DC C3E403      JMP      DOWN

03DF 014802      EPOINT:      LXI      B,      M5E
03E2 3ED8         MVI      A,      0D9H

03E4 C5          DOWN:      PUSH     B
03E5 322401      STA      COUNT
03E8 C609      ADI      9H
03EA 32A008      STA      MEMORY+20H
03ED 118708      LXI      D,      MEMORY+7
03F0 CDF404      CALL     KEY
03F3 C1          POP      B
03F4 FE0D      CPI      CR
03F6 CAFF03      JZ      DLOOP
03F9 CDFC04      CALL     OOPS
03FC C39503      JMP      DATPT

;
; DLOOP:
;
03FF 0A          COPY NUMBER DATA POINTS INTO RECORD
0400 FE09      B
0402 CA0B04      09H
0405 12      DLEND
0406 03      D
0407 13      B
0408 C3FF03      D
           JMP      DLOOP

DLEND:      MVI      A,      '$'
           STAX     D
           INX      D

;
; GET PARAMETERS AND SAVE FOR THE RECORD
;

```



```

0441 3E24      MVI    A,      'S'
0443 12        STAX   D

; BEGIN:
0444 CD5E04    CALL   DMASET   ;SETS UP DMA AND ST800
0447 D342     OUT    DMA+2H    ;RUNS ONE SCAN

; NOW READY TO BEGIN SCANNING WHEN PROMPTED
0449 117701    LXI    D,      MSG3
044C 0E09      MVI    C,      9H
044E CD0500    CALL   BDOS

; RESET DMA WORD LENGTH REG AND MEMORY ADDR REG,
; CHANGE COMMAND WORD TO GIVE DMA COMPLETE
; CONTROL OF THE SYSTEM BUS
0451 D349     OUT    DMA+9H
0453 CD6E04    CALL   SYNC     ;RESETS DMA FOR RUN
0456 3E37      MVI    A,      DMACMD+00100000B
0458 D34A     OUT    DMA+0AH

; DATA ACQUISITION STARTS WITH PULSE GENERATOR
; NOTHING TO DO BUT WAIT
; WAIT:
045A AF        XRA    A
045B C35A04    JMP    WAIT

; END OF MAIN PROGRAM
;
;
;
;
;
;
;

```





```

046E AF      ; SYNC:
046F D34C    A      DMA+0CH      ;LSB OF LENGTH REG
0471 3A2401  OUT     COUNT      ;MSB OF LENGTH REG
0474 D34D    OUT     DMA+0DH
0476 210009  LXI     H,          MEMORY+80H
0479 7D      MOV     A,          L      ;LSB OF MEMORY ADDR
047A D34E    OUT     DMA+0EH      ;MSB OF MEMORY ADDR
047C 7C      MOV     A,          H
047D D34F    OUT     DMA+0FH      ;ENABLE INTERRUPTS
047F FB      EI
0480 C9      RET

; DMA NOW READY TO GO WHEN COMMAND WORD IS ISSUED
; RESET4:
0481 D349    OUT     DMA+9H      ;RESET DMA
0483 3E20    MVI     A,          ;CLEAR INT 4 FROM CPU
0485 D3FD    OUT     0FDH        ;INTERRUPT PENDING STACK
0487 F1      POP     PSW        ;KEEP STACK STRAIGHT
0488 113D03  LXI     D,          ;GET USER TO TURN OFF
048B 0E09    MVI     C,          ;PULSE GENERATOR
048D CD0500  CALL    BDOS       ;REENABLES INTERRUPTS
0490 FB      EI               ;GO PROCESS DATA
0491 C30705  JMP     DONE

; ROUTINE TO READ IN INITIAL AND FINAL CHANNELS
; DIGIT1:
0494 114501  LXI     D,          MSG1
0497 0E09    MVI     C,          9
0499 CD0500  CALL    BDOS
049C CDF404  CALL    KEY
049F FE0D    CPI     CR
04A1 CA9404  JZ      DIGIT1

```



```

;
;
; ROUTINE TO RETRIEVE CHARACTER FROM KEYBOARD
;
; KEY:
04F4 D5
04F5 0E01
04F7 CD0500
04FA D1
04FB C9

PUSH D
MVI C, 1H
CALL BDOS
POP D
RET

;
;
; ROUTINE PRINTS MESSAGE IF TOO MANY CHARACTERS
;
; OOPS:
04FC D5
04FD 119601
0500 0E09
0502 CD0500
0505 D1
0506 C9

PUSH D
LXI D, MSG4
MVI C, 9
CALL BDOS
POP D
RET

;
;
; DONE:
0507 119202
050A 0E09
050C CD0500
050F CDF404
0512 FE4E
0514 CA2005
0517 CD0606
051A CD0606
051D C36C05

LXI D, MSG7
MVI C, 9H
CALL BDOS
CALL KEY, 'N'
CPI GETMOR
JZ CRLF
CALL CRLF
CALL CRLF
JMP FLFILE

; SEE IF USER WANTS
; FILE WRITTEN
; CHECK ANSWER
; IF NO, CONTINUE
; IF YES, GO WRITE

;
;
; GETMOR:

```

ADDRESS	INSTR	OPERAND	COMMENT
0520	11B502		
0521	0E09		
0522	0E09		
0523	CD0500		
0524	CD0500		
0525	CD0500		
0526	CD0500		
0527	CD0500		
0528	CD0500		
0529	CD0500		
0530	CD0500		
0531	CD0500		
0532	CD0500		
0533	CD0500		
0534	CD0500		
0535	CD0500		
0536	CD0500		
0537	CD0500		
0538	CD0500		
0539	CD0500		
0540	CD0500		
0541	CD0500		
0542	CD0500		
0543	CD0500		
0544	CD0500		
0545	CD0500		
0546	CD0500		
0547	CD0500		
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0605	CD0500		
0606	CD0500		
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0609	CD0500		
0610	CD0500		
0611	CD0500		
0612	CD0500		
0613	CD0500		
0614	CD0500		
0615	CD0500		
0616	CD0500		
0617	CD0500		
0618	CD0500		
0619	CD0500		
0620	CD0500		
0621	CD0500		
0622	CD0500		
0623	CD0500		
0624	CD0500		
0625	CD0500		
0626	CD		





057B 321101	STA	FLNAME+14	
057E 321201	STA	FLNAME+15	
;CREATE NEW FILE			
0581 0E16	MVI	C,	22
0583 110301	LXI	D,	FLNAME
0586 CD0500	CALL	BDOS	
0589 FEFF	CPI	255	
058B CA2706	JZ	NOROOM	
058E AF	XRA	A	
058F 322301	STA	FLNAME+32	
;CREATE NEW FILE			
;RETURNS 255 IF NOT			
;ENOUGH DISK SPACE			
;ZERO IT			
;NEXT RECORD COUNT			
;WHILE DISK WRITE OCCURS, ECHO DATA FILE PARAMETERS			
;TO CONSOLE FOR CORRELATION			
;			
0592 11AB01	LXI	D,	M45
0595 0E09	MVI	C,	9H
0597 CD0500	CALL	BDOS	
059A CD0606	CALL	CRLF	
059D 118708	LXI	D,	MEMORY+7
05A0 CD1706	CALL	CONSL	
05A3 CD0606	CALL	CRLF	
05A6 D5	PUSH	D	
05A7 116A02	LXI	D,	M6A
05AA 0E09	MVI	C,	9H
05AC CD0500	CALL	BDOS	
05AF D1	POP	D	
05B0 CD0606	CALL	CRLF	
05B3 CD1706	CALL	CONSL	
05B6 CD0606	CALL	CRLF	
05B9 D5	PUSH	D	
05BA 117D02	LXI	D,	M65A
05BD 0E09	MVI	C,	9H
05BF CD0500	CALL	BDOS	
05C2 D1	POP	D	
05C3 CD0606	CALL	CRLF	

```

05C6 CD1706          CALL    CONSL
05C9 CD0606          CALL    CRLF

;
;
;
;SINCE DMA PUT PAIRS OF DATA BYTES INTO MEMORY IN REVERSE
;ORDER, WANT TO REVERSE THEM BEFORE WRITING ON DISK
;
FLIP:
    LDA    MEMORY+20H      ;UPPER LIMIT ON MEMORY
    LXI    H,    MEMORY+80H ;BEGINNING OF DATA
;
FLOP:
    MOV    B,    M      ;GET LSB
    INX    H
    MOV    C,    M      ;GET MSB
    MOV    M,    B      ;PUT LSB
    DCX    H
    MOV    M,    C      ;PUT MSB
    INX    H
    INX    H
    CMP    H
    JNZ    FLOP          ;CHECK AGAINST LIMIT
;
;DATA PAIRS NOW IN CORRECT ORDER
;
;
;READY TO START WRITING ONTO DISK
;
FWRITE:
;
    LXI    D,    MEMORY ;INFO RECORD
;
FLOOP:
    PUSH    D      ;SAVE POINTER
    MVI    C,    26 ;

```

05E4 CD0500	CALL	BDOS	FLNAME	;CHANGE BUFFER ADDRESS
05E7 110301	LXI	D,	21	
05EA 0E15	MVI	C,		
05EC CD0500	CALL	BDOS		;WRITE ONE RECORD
05EF D1	POP	D		;RETRIEVE POINTER
05F0 F5	PUSH	PSW		;WILL CHECK LATER
05F1 218000	LXI	H,	80H	
05F4 19	DAD	D		;INCREMENT POINTER
05F5 EB	XCHG			;BY 80H
05F6 F1	POP	PSW		
05F7 FE00	CPI	0H		;CHECK FOR WRITE ERRORS
05F9 C23506	JNZ	ERROR		
05FC 3AA008	LDA	MEMORY+20H		;CHECK END OF DATA
05FF BA	CMP	D		;MSB ONLY
0600 CA4806	JZ	CLOSE		
0603 C3E105	JMP	FLOOP		;GO DO ANOTHER RECORD
				;THIS CONTINUES UNTIL ALL DATA WRITTEN ONTO DISK
				;ROUTINE PUTS CARRIAGE RETURN, LINE FEED ON CONSOLE
				CRLF:
0606 D5	PUSH	D		
0607 1E0D	MVI	E,	CR	
0609 0E02	MVI	C,	2H	
060B CD0500	CALL	BDOS		
060E 1E0A	MVI	E,	LF	
0610 0E02	MVI	C,	2H	
0612 CD0500	CALL	BDOS		
0615 D1	POP	D		
0616 C9	RET			
				;ROUTINE PRINTS DATA STRINGS ON CONSOLE
				CONSL:
0617 1A	LDAX	D		
0618 13	INX	D		
0619 FE24	CPI	'\$'		





```

*****
END 100H
*****

```

# APPENDIX G

## LINK ASSEMBLY PROGRAM

```

0100      ;
0100      ;
BDOS      EQU C30D04
XON       EQU
XOFF      EQU
CR        EQU
LF        EQU
FF        EQU
EOF       EQU
RUB       EQU
CNTLC     EQU
CNTLD     EQU
CNTLG     EQU
CNTLI     EQU
CNTLP     EQU
CNTLR     EQU
CNTLT     EQU
CNTLU     EQU
FLIMIT    EQU
BUFFMAX   EQU
COUNT:   DS
FCOUNT:   DS
PPREG     DS

;
5H        11H
13H       13H
0DH       0DH
0AH       0AH
0CH       0CH
1AH       1AH
7FH       7FH
03H       03H
04H       04H
07H       07H
09H       09H
10H       10H
12H       12H
14H       14H
15H       15H
230H      230H
0D0000H   0D0000H
2         2
2         2
1         1

UPDATED 1200 ON 26 APR 78
ORG 100H
JMP START
;ENTRY POINT
;END OF LINE FROM VIRTUAL MACHINE
;END OF LINE TO VIRTUAL MACHINE
;CARRIAGE RETURN
;LINE FEED
;FORM FEED
;END OF FILE CHAR FOR DISK WRITE
;DELETE CHARACTER
;WARM BOOT
;RESTORES "DIRECT LINKUP" MODE
;PRINT INSTRUCTIONS
;TAB CHARACTER
;CONTROL P TURNS PRINTER ON AND OFF
;CONTROL R FOR RECEIVE FILE
;CONTROL T FOR TRANSMIT FILE
;DELETE LINE
;ALLOWS 304 RECORDS OF 128 BYTES
;MAX SIZE OF TRANSFERRED FILE
;COUNT OF RECORDS TRANSFERRED
;FILE COUNT RECORD
;PRINTER CONTROL REG;0 OFF,1 ON

```

MSG1:	DB	CR,LF,'DIAL 2721 FOR LINE--CONTROL G FOR INSTRUCTIONS',CR,LF,'\$'			
MSG2:	DB	CONTROL C - REBOOT',CR,LF			
	DB	CONTROL D - RETURN TO DIRECT LINKUP',CR,LF			
	DB	CONTROL G - INSTRUCTIONS',CR,LF			
	DB	CONTROL I - TAB',CR,LF			
	DB	CONTROL P - PRINTER ON/OFF',CR,LF			
	DB	CONTROL R - RECEIVE FILE',CR,LF			
	DB	CONTROL T - TRANSMIT FILE',CR,LF			
	DB	CONTROL U - DELETE LINE',CR,LF			
	DB	RUBOUT - DELETE CHARACTER',CR,LF,'\$'			
	DB	XMIT - INTERRUPT CMS',CR,LF,'\$'			
	DB	CR,LF,'DISK:FILENAME.FILETYPE',CR,LF,'\$'			
MSG3:	DB	CR,LF,'REPEAT',CR,LF,'\$'			
MSG4:	DB	EDIT \$			
MSG5:	DB	FILE NOT FOUND',CR,LF,'>\$'			
MSG6:	DB	TRANSMITTING',CR,LF,'\$'			
MSG7:	DB	TRANSMISSION COMPLETE',CR,LF,'\$'			
MSG8:	DB	FILE\$			
MSG10:	DB	PRINT \$			
MSG11:	DB	NO DIRECTORY SPACE AVAILABLE',CR,LF,'>\$'			
MSG12:	DB	RECEIVING',CR,LF,'\$'			
MSG13:	DB	DISK FULL',CR,LF,'\$'			
MSG14:	DB	RECORDS TRANSFERRED',CR,LF,'>\$'			
MSG15:	DB	CMS FILENAME FILETYPE?',CR,LF,'\$'			
MSG17:	DB	FILE EXCEEDS BUFFER - ONLY 52K BYTES TRANSFERRED',CR,LF,'\$'			
MSG18:	DB	RELOADING',CR,LF,'\$'			
MSG19:	DB	SAVE\$			
STACK:	DS	20			
STKBTM	EQU	\$			

040D	310D04	STAKT:	LXI	SP,	STKBTM	
0410	3E00		MVI	A,	0	
0412	320701		STA	PPREG		;INITIALLY PRINTER IS OFF
0415	110801		LXI	D,	MSG1	
0418	CDAC07		CALL	MESSAGE		;PROMPTS USER TO CALL FOR LINE

[illegible]

ADDRESS	INSTR	OPERANDS	REMARKS
00466	3A0701		
00469	FE00		
0046B	CA7204		
0046E	79		
0046F	CD2C05		
00472	79		
00473	CD6F05		
00476	C32004		
00479	3E3F		
0047B	C9		
0047C	3E08		
0047E	CD3705		
00481	3E40		
00483	C9		
00484	3E5B		
00486	CD6F05		
00489	C39204		
0048C	3E3F		
0048E	CD3705		
00491	C9		
00492	3A0701		
00495	FE00		
00497	CAA404		
0049A	3E0D		
0049C	CD2C05		
0049F	3E0A		
004A1	CD2C05		



04A4 3E13	MVI	A,	XOFF	;END OF LINE CHAR
04A6 CD6F05	CALL	SEND		
04A9 215A0A	CRCV1: ;HL REGISTER POINTS TO ADDR FOR NEXT WORD RECEIVED			
04AC 115A0A	LXI	H,	BUFF	;DE REGISTER POINTS TO ADDR OF NEXT WORD TO BE PRINTED
	LXI	D,	BUFF	;FIFO BUFFER ADDR
04AF CD7A05	CALL	BREAK		
04B2 DB61	IN	61H		;CHECK LINE FOR CHAR
04B4 E602	ANI	02H		
04B6 CA4205	JZ	CKPRT		;IF LINE NOT READY, CHECK IF
				;BUFFER CAUGHT UP
04B9 DB60	IN	60H		;INPUT WORD FROM LINE
04BB E67F	ANI	7FH		
04BD FE11	CPI	XON		;END OF LINE - LET BUFFER
04BF CACC04	JZ	CATCH		;CATCH UP
04C2 FE13	CPI	XOFF		
04C4 CAAF04	JZ	RX1		;FILTER OUT XOFF CHAR
04C7 77	MOV	M,	A	;STORE CHAR
04C8 23	INX	H		
04C9 C3AF04	JMP	RX1		;LOOP UNTIL END OF LINE
04CC 77	MOV	M,	A	;STORE LAST WORD
04CD 1A	LDAX	D		;NEXT WORD TO BE PRINTED
04CE FE11	CPI	XON		
04D0 CA2004	JZ	TX		;GO BACK TO TRANSMIT MODE
04D3 CD3705	CALL	CONOUT		;PRINT ON CONSOLE
04D6 3A0701	LDA	PPREG		;CHECK IF PRINTER ON
04D9 FE00	CPI	0		

04DB CAE204	JZ	BACK	
04DE 1A	LDAX	D	
04DF CD2C05	CALL	DRIVER	
04E2 13	INX	D	
04E3 C3CD04	JMP	LOOP	
04E6 113D01	LXI	D,	MSG2
04E9 1A	LDAX	D	
04EA FE24	CPI	'\$'	
04EC CA2004	JZ	TX	
04EF CD3705	CALL	CONOUT	A
04F2 47	MOV	B,	
04F3 3A0701	LDA	PPREG	
04F6 FE00	CPI	0	
04F8 CAFF04	JZ	GLP	
04FB 78	MOV	A,	B
04FC CD2C05	CALL	DRIVER	
04FF 13	INX	D	
0500 C3E904	JMP	GLOOP	
0503 3A0701	LDA	PPREG	
0506 FE00	CPI	0	
0508 C22005	JNZ	PRTOFF	
050B CDE505	CALL	USART2	
050E 3E01	MVI	A,	1
0510 320701	STA	PPREG	
0513 3E0D	MVI	A,	CR
0515 CD2C05	CALL	DRIVER	
0518 3E0A	MVI	A,	LF
051A CD2C05	CALL	DRIVER	
051D C32004	JMP	TX	
0520 3E30	MVI	A,	30H

BACK: ;LOOP UNTIL CAUGHT UP  
 GOUGE: ;CHECK IF PRINTER ON OR OFF  
 GLOOP: ;IF ON, WANT TO TURN OFF  
 GLP: ;LATER ROUTINES CHECK THIS ADDR  
 PRTCONT: ;START PRINTER ON NEW LINE  
 PRTOFF: ;RETURN TO TRANSMIT MODE  
 ;CONTROL WORD - TURN PRINTER OFF

0522 D363	OUT 63H		
0524 3E00	MVI A, 0		
0526 320701	STA PPREG		;LATER ROUTINES CHECK THIS ADDR
0529 C32004	JMP TX		
	;ROUTINE TO DRIVE PRINTER USART		
	DRIVER:		
052C F5	PUSH PSW		
	SLO:		
052F 0F	IN 63H		;WAIT UNTIL XMITTER READY
0530 D22D05	RRC		
0533 F1	JNC SLO		
0534 D362	POP PSW		
0536 C9	OUT 62H		
	RET		
	;ROUTINE TO DRIVE CONSOLE USART		
	CONOUT:		
0537 F5	PUSH PSW		
	SLO2:		
0538 DBF7	IN 0F7H		
053A 0F	RRC		
053B D23805	JNC SLO2		
053E F1	POP PSW		
053F D3F6	OUT 0F6H		
0541 C9	RET		
	;KEEPS TRACK OF WHICH RECEIVED DATA HAS BEEN PRINTED		
	CKPRT:		
0542 7D	MOV A, L		
0543 BE	CMP E		
0544 CAAF04	JZ RX1		;CAUGHT UP, NO NEED TO PROCEED
0547 DBF7	IN 0F7H		
0549 0F	RRC		
054A D2AF04	JNC RX1		;CONSOLE NOT READY - NO NEED
			;TO PROCEED
054D 3A0701	LDA PPREG		;CHECK IF PRINTER ON
0550 FE00	CPI 0		

[illegible]

**UNCLASSIFIED**

F/G 9/2

NL

2 OF 2  
AD  
A062196

AD  
A062196

100%



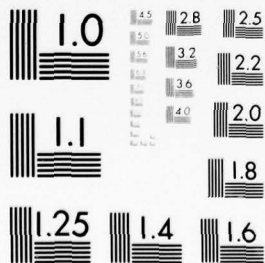
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OF

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AD

A062196



MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A



```

; DATA ADDR OF PTR USART      62H
;
; TWO MORE USARTS AND ONE 8255 PARALLEL INTERFACE AND THEIR TIMERS ARE
; AVAILABLE ON THE 534 BOARD. NEW INTERFACES MUST BE PROGRAMMED BEFORE USE
;
;
; 05AE F3
; 05AF D36F
; 05B1 D36C
; 05B3 CDBB05
; 05B6 CDD805
; 05B9 FB
; 05BA C9
;
; DI
; OUT
; 6FH
; OUT
; 6CH
; CALL
; TIMER
; CALL
; USART
; EI
; RET
;
; DISABLES 8080 INTERRUPTS
; RESETS BOARD
; SELECTS BOARD CONTROL BLOCK
; INITIALIZE PIT CHIPS
; INITIALIZE USARTS
; REENABLES INTERRUPTS
;
; MUST SET UP TIMER CHIPS ACCORDING TO PAGE 3-12 OF 534 MANUAL
;
; CHIP 0 HAS THREE TIMERS ON IT
;
; TIMERS 0 AND 1 OF CHIP 0 ARE CONNECTED TO USARTS 1 AND 2
;
; RESPECTIVELY, DRIVING THE IBM LINE AND THE PRINTER
;
; TIMER:
;
; 05BB D36C
; 05BD 3E36
; 05BF D363
; 05C1 3E40
; 05C3 D360
; 05C5 3E00
; 05C7 D360
; 05C9 3E76
; 05CB D363
; 05CD 3E08
; 05CF D361
; 05D1 3E00
; 05D3 D361
; 05D5 D36D
;
; OUT
; MVI
; 36H
; OUT
; 63H
; MVI
; A,
; 40H
; OUT
; 60H
; MVI
; A,
; 0H
; OUT
; 60H
; MVI
; A,
; 76H
; OUT
; 63H
; MVI
; A,
; 8H
; OUT
; 61H
; MVI
; A,
; 0H
; OUT
; 61H
; OUT
; 6DH
;
; SELECT BOARD CONTROL BLOCK
; SELECT TIMER 0 FOR LINE USART
; ADDR OF COUNTER 0 MODE CONTROL
;
; SET N=40H IN TIMER 0
; CCLK/N=19.2KHZ FOR 1200 BAUD,
; BRP=16X
;
; SELECT TIMER 1 FOR PTR USART
;
; SET N=8 IN TIMER 1
; CCLK/N=153.6KHZ FOR 9600 BAUD,
; BRP=16X
;
; PUTS BOARD IN DATA BLOCK

```

```

05D7 C9                                RET

;
;
;SET UP BOTH USARTS WITH RESETS AND MODE WORDS
;
USART:
04D9 FE00                                CPI 0
05D8 3ECA                                MVI A,
05DA D361                                OUT 61H
05DC 3E5A                                MVI A,
05DE D363                                OUT 63H
05E0 3E37                                MVI A,
05E2 D361                                OUT 61H
05E4 C9                                RET

USART2:
05E5 3E33                                MVI A,
05E7 D363                                OUT 63H
05E9 C9                                RET

;THIS SECTION PERTAINS TO TRANSFERRING COMPLETE
;FILES BETWEEN MDS AND IBM 360
;
FCB EQU
FCBCN EQU
FCBFN EQU
FCBFT EQU
FCBRL EQU
FCBRC EQU
FCB2: DS
FCBCR EQU

5CH EQU
FCB+0 EQU
FCB+1 EQU
FCB+9 EQU
FCB+12 EQU
FCB+15 EQU
33 EQU
FCB+32 EQU

;FCB ADDR
;DISK NAME
;FILENAME(8CHAR)
;FILETYPE (3CHAR)
;REEL NUMBER
;FILE RECORD COUNT (0-127)
;NEW FILENAME AND FILETYPE
;NEXT RECORD NUMBER

;SUBR PROMPTS CONSOLE FOR FILE TO BE XMITTED, SETS UP FILE
;CONTROL BLOCK, OPENS NEW CMS FILE, TRANSMITS FILE, AND
;RETURNS USER TO DIRECT CMS LINKUP
;

```

```

060B 3E00
060D 320301
0610 320401
0613 CD6906
0616 CD7D07
0619 CD1C07
061C CD7D07
061F CD8C07
0622 CDB207
0625 CD7F09
0628 CD3B09
062B CD7809
062E CD3B09
0631 CD280A
0634 CD3B09
0637 CD4608
063A C32004

FILETX:
MVI A, 0
STA COUNT
STA COUNT+1
CALL RESTRT
CALL CRLF
CALL CPNAME
CALL CRLF
CALL OPEN
CALL FILERD
CALL CMS
CALL ANS
CALL XMIT
CALL ANS
CALL FILE
CALL ANS
CALL TALLY
CALL TX
JMP

;SETS UP FILE CONTROL BLOCK
;CP/CMS FILENAME, FILETYPE
;OPENS DISK FILE
;READS DISK FILE
;PREPARES CMS TO RECEIVE FILE
;WAITS FOR ANSWER
;TRANSMITS FILE
;"FILES" FILE IN CMS
;PRINTS OUT RECORD COUNT
;RETURNS TO TRANSMIT MODE

```

```

;SUBR PROMPTS CONSOLE FOR FILE TO BE RECEIVED, SETS UP FILE
;CONTROL BLOCK AND CREATES FILE ON FLOPPY DISK, RECEIVES FILE
;FROM CMS AND ECHOES ON CONSOLE, CLOSSES FILE AND RESTORES
;USER TO DIRECT CMS LINKUP
;

```

```

063D 3E00
063F 320301
0642 320401
0645 CD1C07
0648 CD7D07
064B CD6906
064E CD7D07
0651 CD5A07
0654 CDEB08

FILRX:
MVI A, 0
STA COUNT
STA COUNT+1
CALL CPNAME
CALL CRLF
CALL RESTRT
CALL CRLF
CALL MAKE
CALL BETA

;SETS UP FILE CONTROL BLOCK
;DELETES AND CREATES DISK FILE
;PREPARES CMS TO TRANSMIT FILE

```



0657	CD7D07	CALL	CRLF				
065A	CD8F08	CALL	HAUL				;RECEIVES FILE FROM CMS
065D	CDE907	CALL	FILEWR				;WRITES FILE ON DISK
0660	CD3708	CALL	CLOSE				;CLOSES DISK FILE
0663	CD460E	CALL	TALLY				;PRINTS RECORD COUNT;
0666	C32024	JMP	TX				;RETURNS TO TRANSMIT MODE
;CLEARS OUT OLD FILE CONTROL BLOCK AND SETS UP NEW ONE							
RESTR:							
0669	11DB02	LXI	D, MSG3				
066C	CDAC07	CALL	MESSAGE	0			;PROMPTS "FILENAME.FILETYPE"
066F	3E00	MVI	A, FCB2				
0671	32EA05	STA	FCB2				;PADS NEW FCB
0674	21EB05	LXI	H, FCB2+1				
0677	3E20	MVI	A, 20H				;BLANK CHAR
0679	060B	MVI	B, 11				
PAD1:							
067B	77	MOV	M, A				
067C	23	INX	H				
067D	05	DCR	B				
067E	C27B06	JNZ	PAD1				
0681	3E00	MVI	A, 0				
0683	0604	MVI	B, 4				
0685	21F605	LXI	H, FCB2+12				
PAD2:							
0688	77	MOV	M, A				
0689	23	INX	H				
068A	05	DCR	B				
068B	C28806	JNZ	PAD2				
068E	0E01	MVI	C, 1				
0690	CD0500	CALL	BDOS				
0693	FE41	CPI	'A'				;ASKS FOR DESIRED DISK AND
0695	CAA006	JZ	AONE				;NOTIFIES DISK DRIVE
0698	FE42	CPI	'B'				

069A CAA506		JZ	BONE		
069D C31307		JMP	REPEAT		
AONE:					
06A0 1E00		MVI	E,	0	
06A2 C3AA06		JMP	DSK		
BONE:					
06A5 1E01		MVI	E,	1	
06A7 C3AA06		JMP	DSK		
DSK:					
06AA 0E0E		MVI	C,	14	;CHANGES DISK DRIVE SELECTION
06AC CD0500		CALL	BDOS		
06AF 0E01		MVI	C,	1	
06B1 CD0500		CALL	BDOS		
06B4 FE3A		CPI	;		
06B6 C21307		JNZ	REPEAT		;NEXT CHAR MUST BE ":"
06B9 0609		MVI	B,	9	;IF NOT, START OVER
06BB 21EB05		LXI	H,	FCB2+1	
FNAME:					
06BE C5		PUSH	B		
06BF E5		PUSH	H		
06C0 0E01		MVI	C,	1	
06C2 CD0500		CALL	BDOS		
06C5 E1		POP	H		
06C6 C1		POP	B		
06C7 FE03		CPI	CNTLC		
06C9 CA0000		JZ	00		
06CC FE04		CPI	CNTLD		
06CE CA4F07		JZ	DIRECT		
06D1 FE15		CPI	CNTLU		
06D3 CA0D07		JZ	DUMMY		
06D6 FE2E		CPI	;		
06D8 CAE406		JZ	FTYPE		
06DB 77		MOV	M,	A	

102

0719 C36906	JMP	RESTR	;START OVER
071C 119C03	LXI	MSG15	;PROMPT "CMS FILENAME FILETYPE?"
071F CDAC07	CALL	MESSAGE	
0722 11440A	LXI	D, BUFF40	
0725 D5	PUSH	D	
0726 0E01	MVI	C, 1	
0728 CD0500	CALL	BDOS	
072B D1	POP	D	
072C FE03	CPI	CNTLC	
072E CA0000	JZ	00	
0731 FE04	CPI	CNTLD	
0733 CA4F07	JZ	DIRECT	
0736 FE15	CPI	CNTLU	
0738 CA4907	JZ	DUMMY2	
073B FE0D	CPI	CR	
073D CA4507	JZ	NAME3	
0740 12	STAX	D	
0741 13	INX	D	
0742 C32507	JMP	NAME2	
0745 3E24	MVI	A, '\$'	
0747 12	STAX	D	
0748 C9	RET		
0749 CD7D07	CALL	CRLF	
074C C31C07	JMP	CPNAME	
074F 310D04	LXI	SP, STKBTM	
0752 3E13	MVI	A, XOFF	
0754 CD6F05	CALL	SEND	
0757 C3A904	JMP	CRCV1	
075A 0E13	MVI	C, 19	;DELETE ANY OLD DISK FILE HAVING
075C 11EA05	LXI	D, FCB2	;FILENAME, FILETYPE LISTED IN

[illegible]



07A1 110703	LXI	D, MSG5A	; PROMPTS "FILE NOT FOUND"
07A4 CDAC07	CALL	MESSAGE	
07A7 33	INX	SP	; ADJUSTS STACK POINTER
07A8 33	INX	SP	
07A9 C32004	JMP	TX	; RETURNS TO TRANSMIT MODE
		MESSAGE AT ADDR IN DE ON CONSOLE	
		MESSAGE:	
07AC 0E09	MVI	C, 9	
07AE CD0500	CALL	BDOS	
07B1 C9	RET		
			; READS ENTIRE DISK FILE INTO RAM STARTING AT
			; BUFF (LIMITED TO 52K BYTES)
			FILERD:
			FILERD0:
07B2 213002	LXI	H, FLIMIT	
07B5 220501	SHLD	FCOUNT	
07B8 115A0A	LXI	D, BUFF	
			FILERD1:
07BB D5	PUSH	D	
07BC 0E1A	MVI	C, 26	
07BE CD0500	CALL	BDOS	; CHANGES DMA BUFFER ADDR
07C1 11EA05	LXI	D, FCB2	
07C4 0E14	MVI	C, 20	
07C6 CD0500	CALL	BDOS	; READ FILE RECORD
07C9 D1	POP	D	
07CA F5	PUSH	PSW	
07CB CD7D08	CALL	COUNTER	
07CE 218000	LXI	H, 80H	; INCREMENTS BUFF BY 80H
07D1 19	DAD	D	
07D2 EB	XCHG		
07D3 F1	POP	PSW	
07D4 FE00	CPI	0	
07D6 C0	RNZ		; IF NOT ZERO, EOF CONTAINED IN
			; LAST RECORD
07D7 2A0501	LHLD	FCOUNT	

07DA 2B	DCX	H	F	COUNT	
07DB 220501	SHLD	A,			
07DE 7C	MOV	0			
07DF FE00	CPI				
07E1 C2BB07	JNZ			FILERD1	
07E4 13	INX	D			
07E5 3E13	MVI	A,	XOFF		
07E7 12	STAX	D			
07E8 C9	RET				
	;WRITES DISK FILE BY SAME ALGORITHM AS ABOVE				
	FILEWR:				
07E9 115A0A	LXI	D,	BUFF		
	CONT:				
07EC 0680	MVI	B,	80H		
07EE CD7D08	CALL		COUNTER		
	INLOOP:				
07F1 D5	PUSH	D			
	INLOOP2:				
07F2 1A	LDAX	D			
07F3 FE1A	CPI	EOF			
	;IF EOF, THIS WILL BE LAST				
	;RECORD WRITTEN				
07F5 CA1C08	JZ	LAST			
07F8 13	INX	D			
07F9 05	DCR	B			
07FA C2F207	JNZ			INLOOP2	
07FD D1	POP	D			
07FE D5	PUSH	D			
07FF 0E1A	MVI	C,	26		
0801 CD0500	CALL		BDOS		
0804 11EA05	LXI	D,	FCB2		
0807 0E15	MVI	C,	21		
0809 CD0500	CALL		BDOS		
080C D1	POP	D			
080D F5	PUSH	PSW			
080E 218000	LXI	H,	80H		
0811 19	DAD	D			
	;INCREMENT BUFF BY 80H				
	;WRITE ONE DISK RECORD				
	;CHANGE DMA BUFFER ADDR				

ADDRESS	DATA	OPERATION	STATUS	REMARKS
0812 EB	XCHG	PSW		
0813 F1	POP	1		
0814 FE01	CPI	ERR1		
0816 CA3008	JZ	CONT		
0819 C3EC07	JMP			
;WRITE LAST DISK RECORD				
LAST:				
081C D1	POP	D		
081D 0E1A	MVI	C,	26	
081F CD0500	CALL	BDOS		
0822 11EA05	LXI	D,	FCB2	
0825 0E15	MVI	C,	21	
0827 CD0500	CALL	BDOS		
082A FE01	CPI	1		
082C CA3008	JZ	ERR1		
082F C9	RET			
ERR1:				
0830 117803	LXI	D,	MSG13	
0833 CDAC07	CALL	MESSAGE		
0836 C9	RET			
;CLOSES DISK FILE				
CLOSE:				
0837 11EA05	LXI	D,	FCB2	
083A 0E10	MVI	C,	16	
083C CD0500	CALL	BDOS		
083F 112803	LXI	D,	MSG7	
0842 CDAC07	CALL	MESSAGE		
0845 C9	RET			
;PRINTS OUT RECORD COUNT				
TALLY:				
0846 3A0301	LDA	COUNT		
0849 1F	RAR			
084A 1F	RAR			
084B 1F	RAR			
084C 1F	RAR			
084D E60F	ANI	0FH		

084F C630	ADI	30H
0851 CD3705	CALL	CONOUT
0854 3A0301	LDA	COUNT
0857 E60F	ANI	0FH
0859 C630	ADI	30H
085B CD3705	CALL	CONOUT
085E 3A0401	LDA	COUNT+1
0861 1F	RAR	
0862 1F	RAR	
0863 1F	RAR	
0864 1F	RAR	
0865 E60F	ANI	0FH
0867 C630	ADI	30H
0869 CD3705	CALL	CONOUT
086C 3A0401	LDA	COUNT+1
086F E60F	ANI	0FH
0871 C630	ADI	30H
0873 CD3705	CALL	CONOUT
0876 118403	LXI	D, MSG14
0879 CDAC07	CALL	MESSAGE
087C C9	RET	

;KEEPS TRACK OF RECORDS READ/WRITTEN  
COUNTER:

087D 3A0401	LDA	COUNT+1
0880 C601	ADI	1
0882 27	DAA	
0883 320401	STA	COUNT+1
0886 3A0301	LDA	COUNT
0889 CE00	ACI	0
088B 320301	STA	COUNT
088E C9	RET	

;RECEIVES WORDS FROM LINE USART AND STORES AT BUFF  
HAUL:

088F 116C03	LXI	D, MSG12	; PROMPTS "RECEIVING"
0892 CDAC07	CALL	MESSAGE	
0895 11580A	LXI	D, BUFF-2	; FIRST TWO WORDS WILL BE CR, LF

```

0898 0100D0      LXI B,      BUFFMAX      ;DON'T WANT THEM ON DISK
089B 3E13        MVI A,      XOFF          ;BUFF LIMIT IS 52K BYTES
089D CD6F05      CALL SEND          ;TELL CMS TO START SENDING

;CHECK USART FOR CHARACTER
FRX1:
08A0 DB61        IN 61H
08A2 E602        ANI 2
08A4 CAA0J8      JZ FRX1
08A7 DB60        IN 60H
08A9 FE11        CPI XON
08AB CAD506      JZ MARK
08AE FE13        CPI XOFF
08B0 CAA008      JZ FRX1
08B3 FE7F        CPI 7FH
08B5 CAA008      JZ FRX1
08B8 CD3705      CALL CONOUT
08BB 12          STAX D
08BC 13          INX D
08BD 0B          DCX B
08BE 78          MOV A, B
08BF FE00        CPI 0
08C1 CAE108      JZ EXCEED
08C4 CDCA08      CALL BREAK2
08C7 C3A008      JMP FRX1              ;LOOP FOREVER

;CHECK KEYBOARD FOR INTERRUPT
;IF INTERRUPT EXISTS, RESET STACK POINTER
;AND JUMP TO DIRECT LINKUP MODE
;WHERE INTERRUPT CONDITION WILL BE NOTED
;AND A SIGNAL SENT TO CMS
BREAK2:
08CA DBF7        IN 0F7H
08CC E602        ANI 2
08CE C8          RZ
08CF 310D04      LXI SP,      STKBTM
08D2 C3A904      JMP CRCV1

```



```

08D5 1A      ;MARK END OF FILE WITH "EOF"
08D6 1B      ;LAST CHARS RECEIVED ARE CR,LF,NULL,R;>
08D7 FE52    ;WANT TO BACK UP TO LAST VALID WORD
08D9 C2D508  MARK:
08DC 13      LDAX D
08DD 3E1A    DCX D
08DF 12      CPI 'R'
08E0 C9      JNZ MARK
           INX D
           MVI A, EOF
           STAX D
           RET

EXCEED:      LXI D, MSG17 ;PROMPTS "BUFFER LIMIT EXCEEDED"
           CALL MESSAGE
           MVI A, EOF
           STAX D
           RET

;SENDS "PRINT" TO CMS
BETA:        LXI D, MSG10
           LDAX D
           CPI '$'
           JZ DELTA
           CALL CONOUT
           CALL SEND
           INX D
           JMP GAMMA

;SENDS "FILENAME FILETYPE" TO CMS
DELTA:       LXI D, BUFF40
           LDAX D
           CPI '$'

EPSILON:     LDAX D
           CPI '$'
08E1 11B503  GAMMA:
08E4 CDAC07  LDAX D
08E7 3E1A    CPI '$'
           JZ DELTA
           CALL CONOUT
           CALL SEND
           INX D
           JMP GAMMA

08E9 12      ;SENDS "FILENAME FILETYPE" TO CMS
08EA C9      DELTA:
           LXI D, BUFF40
           LDAX D
           CPI '$'

08EB 114503  EPSILON:
08EE 1A      LDAX D
08EF FE24    CPI '$'
08F1 CAFE08  JZ DELTA
08F4 CD3705  CALL CONOUT
08F7 CD6F05  CALL SEND
08FA 13      INX D
08FB C3EE08  JMP GAMMA

08FE 11440A  ;SENDS "FILENAME FILETYPE" TO CMS
0901 1A      DELTA:
0902 FE24    LXI D, BUFF40
           LDAX D
           CPI '$'

```

ADDRESS	INSTR	OPERAND	COMMENT
0004 C8	RZ		
0005 CD3705	CALL	CONOUT	
0006 CD6F05	CALL	SEND	
000B 13	INX	D	
000C C30109	JMP	EPSILON	
;SETS UP CMS TO RECEIVE FILE BY COMMANDING			
;EDIT FILENAME FILETYPE			
CMS:			
000F 110103	LXI	D, MSG5	
CMS2:			
0012 1A	LDAX	D	
0013 FE24	CPI	'\$'	
0015 CA2209	JZ	CMS3	
0016 CD3705	CALL	CONOUT	
001B CD6F05	CALL	SEND	
001E 13	INX	D	
001F C31209	JMP	CMS2	
CMS3:			
CMS4:			
0022 11440A	LXI	D, BUFF40	
CMS5:			
0025 1A	LDAX	D	
0026 FE24	CPI	'\$'	
0028 CA3509	JZ	CMS5	
002B CD3705	CALL	CONOUT	
002E CD6F05	CALL	SEND	
0031 13	INX	D	
0032 C32509	JMP	CMS4	
CMS5:			
0035 3E13	MVI	A, XOFF	
0037 CD6F05	CALL	SEND	
003A C9	RET		
;ECHOES CMS ANSWER TO CONSOLE			
ANS:			
003B DB61	IN	61H	
003D E602	ANI	2	
003F CA3B09	JZ	ANS	

0942 DB60	IN	60H	
0944 FE11	CPI	XON	
0946 C8	RZ		
0947 FE13	CPI	XOFF	; FILTERS OUT XOFF
0949 CA3B09	JZ	ANS	
094C CD3705	CALL	CONOUT	
094F C33B09	JMP	ANS	
	; RECEIVES CMS ANSWERS AND ECHOES TO CONSOLE		
	; FILTERS OUT XOFF, CR, LF, AND >		
	ANS2:		
0952 DB61	IN	61H	
0954 E602	ANI	2	
0956 CA5209	JZ	ANS2	
0959 DB60	IN	60H	
095B FE11	CPI	XON	
095D C8	RZ		
095E FE13	CPI	XOFF	
0960 CA5209	JZ	ANS2	
0963 FE0D	CPI	CR	
0965 CA5209	JZ	ANS2	
0968 FE0A	CPI	LF	
096A CA5209	JZ	ANS2	
096D FE3E	CPI	'>	
096F CA5209	JZ	ANS2	
0972 CD3705	CALL	CONOUT	
0975 C35209	JMP	ANS2	
	; TRANSMITS FILE TO CMS		
	XMIT:		
0978 111903	LXI	MSG6	; PROMPTS "TRANSMITTING"
097B CDAC07	CALL	MESSAGE	
097E CD1D0A	CALL	PAUSE	; DELAY 100 MICROSECS AT
0981 115A0A	LXI	D,	; BEGINNING OF EACH LINE
0984 0E83	MVI	C,	; 132 BYTES
	XMIT2:		
0986 1A	LDAX	D	
0987 FE1A	CPI	EOF	; IF EOF, TRANSMISSION FINISHED

0989 CAAF09	JZ	XMIT3		
098C FE13	CPI	XOFF		;IF TEMPORARY EOF, MORE DISK
				;FILE REMAINS
098E CAC909	JZ	XMIT4		
0991 FE0D	CPI	CR		;CLOSE OUT LINE AT CARR RETURN
0993 CA080A	JZ	ENDLN		
0996 FE0A	CPI	LF		;FILTER OUT LINEFEEDS
0998 CAA809	JZ	SKIP		
099B FE09	CPI	09H		;CHANGE TAB CHAR TO "?"
099D CC7904	CZ	CHNG1		
09A0 47	MOV	B,	A	
09A1 CD6F05	CALL	SEND		
09A4 0D	DCR	C		
09A5 CA0C0A	JZ	ENDLN2		;IF 132 CHARS EXCEEDED, CMS
				;BUFFER CHOKES
	SKIP:			
09A8 13	INX	D		
09A9 CDF909	CALL	BREAK3		
09AC C38609	JMP	XMIT2		
	XMIT3:			
09AF 112803	LXI	D,	MSG7	;PROMPTS "TRANSMISSION COMPLETE"
09B2 CDAC07	CALL	MESSAGE		
	XMIT35:			
09B5 CD1D0A	CALL	PAUSE		
09B8 3E13	MVI	A,	XOFF	;SENDS DOUBLE XOFF TO SHIFT
09BA CD6F05	CALL	SEND		;CMS FROM INPUT TO EDIT MODE
09BD CD5209	CALL	ANS2		;WAIT FOR ANSWER AND DELAY
09C0 CD1D0A	CALL	PAUSE		
09C3 3E13	MVI	A,	XOFF	
09C5 CD6F05	CALL	SEND		
09C8 C9	RET			
				;FOR FILES EXCEEDING 52K, PROGRAM SHIFTS
				;CMS TO EDIT MODE AND ISSUES "SAVE" COMMAND
				;AT THIS POINT - CMS SAVES TRANSMITTED DATA
				;AND RETURNS TO INPUT MODE, AT WHICH TIME
				;PROGRAM READS NEXT SECTION OF FILE AND TRANSMITS

ADDRESS	INSTR	OPERAND	COMMENT
09C9	CDB5A9		
09CC	CD3B09		
09CF	CD1D0A		
09D2	11F403		
09D5	1A		
09D6	FE24		
09D8	CAE509		
09DB	CD3705		
09DE	CD6F05		
09E1	13		
09E2	C3D509		
09E5	3E13		
09E7	CD6F05		
09EA	CD3B09		
09ED	11E803		
09F0	CDAC07		
09F3	CDB207		
09F6	C37809		
09F9	DBF7		
09FB	E602		
09FD	C8		
09FE	DBF6		
0AA0	E67F		
0AA2	FE04		
0A04	C0		
0AA5	C34F07		
0A08	B8		
0A09	CAA809		
0A0C	47		
09C9	CALL	XMIT35	
09CC	CALL	ANS	
09CF	CALL	PAUSE	
09D2	LXI	D,	MSG19
09D5	LDAX	D,	
09D6	CPI	'\$'	
09D8	JZ	XMIT6	
09DB	CALL	CONOUT	
09DE	CALL	SEND	
09E1	INX	D	
09E2	JMP	XMIT5	
09E5	MVI	A,	XOFF
09E7	CALL	SEND	
09EA	CALL	ANS	
09ED	LXI	D,	MSG18
09F0	CALL	MESSAGE	
09F3	CALL	FLITERD0	
09F6	JMP	XMIT	
09F9	IN	0F7H	
09FB	ANI	2	
09FD	RZ		
09FE	IN	0F6H	
0AA0	ANI	7FH	
0AA2	CPI	CNTLD	
0A04	RNZ		
0AA5	JMP	DIRECT	
0A08	XOFF	AFTER EACH LINE	
0A09	ENDLN:		
0A0C	ENDLN2:		
09C9	CMP	B	
09CC	JZ	SKIP	
09CF	MOV	B,	A





# APPENDIX H

## DATLINK

```

; UPDATED 14 AUG 78      VERS 73

ORG 100H
JMP START
BDOS EQU
XON EQU
XOFF EQU
CR EQU
LF EQU
FF EQU
EOF EQU
BUFF EQU
CONV EQU
RUB EQU
CNTLC EQU
CNTLD EQU
CNTLG EQU
CNTLI EQU
CNTLP EQU
CNTLR EQU
CNTLT EQU
CNTLU EQU
PPREG: DS

5H      ; ENTRY POINT
11H     ; END OF LINE FROM VIRTUAL MACHINE
13H     ; END OF LINE TO VIRTUAL MACHINE
0DH     ; CARRIAGE RETURN
0AH     ; LINE FEED
0CH     ; FORM FEED
1AH     ; END OF FILE CHAR FOR DISK WRITE
880H    ; START OF MEMORY BUFFER
0FE0EH  ; MONITOR CONVERSION ROUTINE
7FH     ; DELETE CHARACTER
03H     ; WARM BOOT
04H     ; RESTORES "DIRECT LINKUP" MODE
07H     ; PRINT INSTRUCTIONS
09H     ; TAB CHARACTER
10H     ; CONTROL P TURNS PRINTER ON AND OFF
12H     ; CONTROL R FOR RECEIVE FILE
14H     ; CONTROL T FOR TRANSMIT FILE
15H     ; DELETE LINE
1       ; PRINTER CONTROL REG; 0 OFF, 1 ON

```





0402 CDBF04	CALL	DRIVER	
0405 79	MOV	A,	C
0406 CD0205	CALL	SEND	
0409 C3B303	JMP	TX	
			;SENDS CHAR TO VIRTUAL MACHINE
			;LOOPS FOREVER
CHNG1:	MVI	A,	'?
040C 3E3F	RET		
040E C9			
CHNG2:	MVI	A,	08H
040F 3E08	CALL	CONOUT	
0411 CDCA04	MVI	A,	'Q'
0414 3E40	RET		
0416 C9			
CHNG3:	MVI	A,	'['
0417 3E5B	CALL	SEND	
0419 CD0205	JMP	RCV	
041C C32504			
CHNG4:	MVI	A,	'?
041F 3E3F	CALL	CONOUT	
0421 CDCA04	RET		
0424 C9			
	;RECEIVE MODE		
	;RCV:		
0425 3A0301	LDA	PPREG	
0428 FE00	CPI	0	
042A CA3704	JZ	CRCV	
042D 3E0D	MVI	A,	CR
042F CDBF04	CALL	DRIVER	
0432 3E0A	MVI	A,	LF
0434 CDBF04	CALL	DRIVER	
	;CHECK IF PRINTER ON		
	;START NEW LINE ON PRINTER		
CRCV:	MVI	A,	XOFF
0437 3E13	CALL	SEND	
0439 CD0205			;END OF LINE CHAR
CRCV1:			







04BC C3B303	JMP TX	
	;ROUTINE TO DRIVE PRINTER USART	
04BF F5	DRIVER: PUSH PSW	
04C0 DB63	SLO: IN 63H	;WAIT UNTIL XMITTER READY
04C2 0F	RRC	
04C3 D2C004	JNC SLO	
04C6 F1	POP PSW	
04C7 D362	OUT 62H	
04C9 C9	RET	
04CA F5	PUSH PSW	
04CB DBF7	SLO2: IN 0F7H	
04CD 0F	RRC	
04CE D2CB04	JNC SLO2	
04D1 F1	POP PSW	
04D2 D3F6	OUT 0F6H	
04D4 C9	RET	
;ROUTINE TO DRIVE CONSOLE USART		
CONOUT:		
;KEEPS TRACK OF WHICH DATA HAS BEEN PRINTED		
04D5 7D	CKPRT: MOV A, L	
04D6 BB	CMP E	
04D7 CA4204	JZ RX1	;CAUGHT UP - NO NEED TO PROCEED
04DA DBF7	IN 0F7H	
04DC 0F	RRC	
04DD D24204	JNC RX1	;CONSOLE NOT READY - NO NEED TO PROCEED
04E0 3A0301	LDA PPRG	;PROCEED
04E3 FE00	CPI 0	;CHECK PRINTER ON
04E5 CAEE04	JZ CKP2	;PRINTER NOT ON - NO NEED TO PROCEED
04E8 DB63	IN 63H	

04EA 0F	RRC	RX1			
04EB D24204	JNC				;PRINTER NOT READY - NO NEED TO ;PROCEED
CKP2:					
04EE 1A	LDAX	D			;NEXT WORD TO BE PRINTED
04EF D3F6	OUT	0F6H			;OUT TO CONSOLE
04F1 D362	OUT	62H			;OUT TO PRINTER
04F3 13	INX	D			
04F4 7D	MOV	A,	L		;CHECK AGAIN TO SEE IF BUFFER IS
04F5 BB	CMP	E			;CAUGHT UP - IF SO, RESET BUFFER
04F6 C24204	JNZ	RX1			
04F9 218008	LXI	H,		BUFF	
04FC 118008	LXI	D,		BUFF	
04FF C34204	JMP	RX1			
;DRIVES USART ON HIGH SPEED LINE					
0502 F5	PUSH	PSW			SEND:
0503 DB61	IN	61H			WAIT:
0505 0F	RRC				
0506 D20305	JNC	WAIT			
0509 F1	POP	PSW			
050A D360	OUT	60H			
050C C9	RET				
;CHECKS KEYBOARD FOR INTERRUPT					
BREAK:					
050D DBF7	IN	0F7H			
050F E602	ANI	2			
0511 C8	RZ				
0512 DBF6	IN	0F6H			;IF NONE, GO TO RECEIVE MODE
0514 E67F	ANI	7FH			;INTRPT PRESENT, CHECK IF BREAK
0516 FE11	CPI	XON			
0518 C0	RNZ				;IGNORE IF NOT BREAK
0519 3E3F	MVI	A,	3FH		;CONTROL - DRIVES XMIT LINE LOW
051B D361	OUT	61H			;HOLD LINE LOW FOR 2 WORDLENGTHS
051D 010004	LXI	B,	400H		;WAIT 10 MILLISECS

```

0520 0B      DLA1:  DCX      B      B
0521 78      MOV      A,      B
0522 FE00    CPI      0
0524 CA3205  JZ       DLA3
0527 DB61    IN       61H
0529 E602    ANI      2
052B CA2005  JZ       DLA1
052E DB60    IN       60H
0530 77      MOV      M,      A
0531 23      INX      H
                ;CHECK LINE FOR CHAR

0532 01A005  DLA3:  LXI      B,    5A0H      ;DELAY 16 MILLISEC

0535 0B      DLA2:  DCX      B      B
0536 78      MOV      A,      B
0537 FE00    CPI      0
0539 C23505  JNZ      DLA2

053C 3E37    RESET:  MVI      A,    37H
053E D361    OUT      61H
0540 C9      RET

BOARD:

```

THIS ROUTINE INITIALIZES THE 534 BOARD, THE TIMERS, AND THE TWO USARTS  
NEEDED TO DRIVE THE IBM HIGH SPEED LINE AND THE MODEL 40 PRINTER

```

BASE ADDR OF 534 BOARD      60H
CMD ADDR OF LINE USART      61H
DATA ADDR OF LINE USART     60H
CMD ADDR OF PTR USART       63H
DATA ADDR OF PTR USART      62H

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;
;
;SET UP BOTH USARTS WITH RESETS AND MODE WORDS
;
USART:
056B 3ECA          MVI A, 0CAH ;2 STOP, PAR DISABLED, 7 BITS
056D D361          OUT 61H
056F 3E5A          MVI A, 5AH  ;1 STOP, PAR DISABLED, 7 BITS
0571 D363          OUT 63H
0573 3E37          MVI A, 37H
0575 D361          OUT 61H
0577 C9            RET

USART2:
0578 3E33          MVI A, 33H
057A D363          OUT 63H
057C C9            RET

;THIS SECTION PERTAINS TO TRANSFERRING COMPLETE
;FILES BETWEEN MDS AND IBM 360
;
SCH EQU 5CH
FCB+0 EQU FCB+0 ;FCB ADDR
FCB+1 EQU FCB+1 ;DISK NAME
FCB+9 EQU FCB+9 ;FILENAME(8CHAR)
FCB+12 EQU FCB+12 ;FILETYPE (3CHAR)
FCB+15 EQU FCB+15 ;REEL NUMBER
FCB+33 EQU FCB+33 ;FILE RECORD COUNT (0-127)
FCB+32 EQU FCB+32 ;NEW FILENAME AND FILETYPE
FCB+32 EQU FCB+32 ;NEXT RECORD NUMBER

;SUBR PROMPTS CONSOLE FOR FILE TO BE XMITTED, SETS UP FILE
;CONTROL BLOCK, OPENS NEW CMS FILE, TRANSMITS FILE, AND
;RETURNS USER TO DIRECT CMS LINKUP
;
FILETX:
059E CDD105        CALL RSTRT ;SETS UP FILE CONTROL BLOCK

```

05A1 CDC706	CALL	CRLF	
05A4 CD8906	CALL	CPNAME	;CP/CMS FILENAME, FILETYPE
05A7 CDC706	CALL	CRLF	
05AA CDD206	CALL	OPEN	;OPENS DISK FILE
05AD CD0307	CALL	FILERD	;READS DISK FILE
05B0 CD2207	CALL	ECHO	;ECHO FILE INFO
05B3 CD5F07	CALL	CMS	;PREPARES CMS TO RECEIVE FILE
05B6 CD8B07	CALL	ANS	;WAITS FOR ANSWER
05B9 CDC807	CALL	XMIT	;TRANSMITS FILE
05BC CD8B07	CALL	ANS	
05BF CD3C08	CALL	FILE	; "FILES" FILE IN CMS
05C2 CD8B07	CALL	ANS	
05C5 C3B303	JMP	TX	;RETURNS TO TRANSMIT MODE

;THIS PROGRAM DOES NOT HAVE RECEIVE FILE MODE  
FILERX:

05C8 112703	LXI	D,	MSG10
05CB CDF206	CALL	MESSAGE	
05CE C3B303	JMP	TX	

;CLEARS OUT OLD FILE CONTROL BLOCK AND SETS UP NEW ONE  
RESTR1:

05D1 11AF02	LXI	D,	MSG3			
05D4 CDF206	CALL	MESSAGE				;PROMPTS "FILENAME.FILETYPE"
05D7 3E00	MVI	A,	0			
	STA	FCB2				;PADS NEW FCB
05DC 217E05	LXI	H,	FCB2+1			
05DF 3E20	MVI	A,	20H			;BLANK CHAR
05E1 060B	MVI	B,	11			
	PAD1:					
05E3 77	MOV	M,	A			
05E4 23	INX	H				
05E5 05	DCR	B				
05E6 C2E305	JNZ	PAD1				

05E9 3E00	MVI	A,	0	
05EB 0604	MVI	B,	4	
05ED 216905	LXI	H,	FCB2+12	
05F0 77	MOV	M,	A	
05F1 23	INX	H		
05F2 05	DCR	B		
05F3 C2F005	JNZ	PAD2		
05F6 0E01	MVI	C,	1	
05F8 CD0500	CALL	BDOS		
05FB FE41	CPI	'A'		
05FD CA0D06	JZ	AONE		
0600 FE42	CPI	'B'		
0602 CA1206	JZ	BONE		
0605 FE04	CPI	CNTLD		
0607 CABC06	JZ	DIRECT		
060A C3E006	JMP	REPEAT		
060D 1E00	MVI	E,	0	
060F C31706	JMP	DSK		
0612 1E01	MVI	E,	1	
0614 C31706	JMP	DSK		
0617 0E0E	MVI	C,	14	
0619 CD0500	CALL	BDOS		
061C 0E01	MVI	C,	1	
061E CD0500	CALL	BDOS		
0621 FE3A	CPI	;		
0623 C28006	JNZ	REPEAT		
0626 0609	MVI	B,	9	

PAD2:

AONE:

BONE:

DSK:

;ASKS FOR DESIRED DISK  
;AND NOTIFIES DISK DRIVE

;CHANGES DISK DRIVE SELECTION

;NEXT CHAR MUST BE " : "  
;IF NOT, START OVER

ADDRESS	INSTR	OPERAND	COMMENT
0000	0000	0000	0000
0001	0000	0000	0000
0002	0000	0000	0000
0003	0000	0000	0000
0004	0000	0000	0000
0005	0000	0000	0000
0006	0000	0000	0000
0007	0000	0000	0000
0008	0000	0000	0000
0009	0000	0000	0000
000A	0000	0000	0000
000B	0000	0000	0000
000C	0000	0000	0000
000D	0000	0000	0000
000E	0000	0000	0000
000F	0000	0000	0000
0010	0000	0000	0000
0011	0000	0000	0000
0012	0000	0000	0000
0013	0000	0000	0000
0014	0000	0000	0000
0015	0000	0000	0000
0016	0000	0000	0000
0017	0000	0000	0000
0018	0000	0000	0000
0019	0000	0000	0000
001A	0000	0000	0000
001B	0000	0000	0000
001C	0000	0000	0000
001D	0000	0000	0000
001E	0000	0000	0000
001F	0000	0000	0000
0020	0000	0000	0000
0021	0000	0000	0000
0022	0000	0000	0000
0023	0000	0000	0000
0024	0000	0000	0000
0025	0000	0000	0000
0026	0000	0000	0000
0027	0000	0000	0000
0028	0000	0000	0000
0029	0000	0000	0000
002A	0000	0000	0000
002B	0000	0000	0000
002C	0000	0000	0000
002D	0000	0000	0000
002E	0000	0000	0000
002F	0000	0000	0000
0030	0000	0000	0000
0031	0000	0000	0000
0032	0000	0000	0000
0033	0000	0000	0000
0034	0000	0000	0000
0035	0000	0000	0000
0036	0000	0000	0000
0037	0000	0000	0000
0038	0000	0000	0000
0039	0000	0000	0000
003A	0000	0000	0000
003B	0000	0000	0000
003C	0000	0000	0000
003D	0000	0000	0000
003E	0000	0000	0000
003F	0000	0000	0000
0040	0000	0000	0000
0041	0000	0000	0000
0042	0000	0000	0000
0043	0000	0000	0000
0044	0000	0000	0000
0045	0000	0000	0000
0046	0000	0000	0000
0047	0000	0000	0000
0048	0000	0000	0000
0049	0000	0000	0000
004A	0000	0000	0000
004B	0000	0000	0000
004C	0000	0000	0000
004D	0000	0000	0000
004E	0000	0000	0000
004F	0000	0000	0000
0050	0000	0000	0000
0051	0000	0000	0000
0052	0000	0000	0000
0053	0000	0000	0000
0054	0000	0000	0000
0055	0000	0000	0000



0669 FE15	CPI	CNTLU	
066B CA7A06	JZ	DUMMY	
066E FE0D	CPI	CR	
0670 C8	RZ		
0671 77	MOV	M,	A
0672 23	INX	H	
0673 05	DCR	B	
0674 CA8006	JZ	REPEAT	
0677 C35606	JMP	FTYPE1	
	DUMMY:		
067A CDC706	CALL	CRLF	
067D C3D105	JMP	RESTR	
	REPEAT:		
0680 11C902	LXI	MSG4	
0683 CDF206	CALL	MESSAGE	
0686 C3D105	JMP	RESTR	
	CPNAME:		
0689 117303	LXI	MSG15	
068C CDF206	CALL	MESSAGE	
068F 115808	LXI	D,	BUFF40
	NAME2:		
0692 D5	PUSH	D	
0693 0E01	MVI	C,	1
0695 CD0500	CALL	BDOS	
0698 D1	POP	D	
0699 FE03	CPI	CNTLC	
069B CA0000	JZ	00	
069E FE04	CPI	CNTLD	
06A0 ABC006	JZ	DIRECT	
06A3 FE15	CPI	CNTLU	
06A5 CAB606	JZ	DUMMY2	
06A8 FE0D	CPI	CR	
06AA CAB206	JZ	NAME3	
06AD 12	STAX	D	
06AE 13	INX	D	
06AF C39206	JMP	NAME2	

;IF FILETYPE EXCEEDS 3 CHAR,  
;START OVER

;PROMPTS "REPEAT"

;START OVER

;PROMPTS "CMS FILENAME FILETYPE?"

06B2 3E24	NAME3:	MVI	A,	
06B4 12		STAX	D	
06B5 C9		RET		
06B6 CDC706	DUMMY2:	CALL	CRLF	
06B9 C38906		JMP	CPNAME	
06BC 31A003	DIRECT:	LXI	SP,	STKBTM
06BF 3E13		MVI	A,	XOFF
06C1 CD0205		CALL	SEND	
06C4 C33C04		JMP	CRCV1	
06C7 3E0D	CRLF:	MVI	A,	CR
06C9 CDCA04		CALL	CONOUT	
06CC 3E0A		MVI	A,	LF
06CE CDCA04		CALL	CONOUT	
06D1 C9		RET		
06D2 117D05	OPEN:	LXI	D,	FCB2
06D5 0E0F		MVI	C,	15
06D7 CD0500		CALL	BDOS	
06DA FEFF		CPI	255	
06DC CAE706		JZ	BADF	
06DF AF		XRA	A	
06E0 329D05		STA	FCB2+32	
06E3 CDC706		CALL	CRLF	
06E6 C9		RET		
06E7 11DA02	BADF:	LXI	D,	MSG5A
06EA CDF206		CALL	MESSAGE	
06ED 33		INX	SP	
06EE 33		INX	SP	
06EF C3B303		JMP	TX	

;OPENS DISK FILE FOR READING  
 ;ZERO INDICATES NO SUCH FILE  
 ;ZEROS FILE RECORD COUNTER  
 ;PROMPTS "FILE NOT FOUND"  
 ;ADJUSTS STACK POINTER  
 ;RETURNS TO TRANSMIT MODE

```

06F2 0E09      MESSAGE: MVI C, 9
06F4 CD0500    CALL BDOS
06F7 C9        RET

06F8 1A        MESS2: LDAX D
06F9 13        INX D
06FA FE24      CPI '$'
06FC C8        RZ
06FD CDCA04    CALL CONOUT
0700 C3F806    JMP MESS2

;READS ENTIRE DISK FILE INTO RAM STARTING AT
;BUFF (LIMITED TO 52K BYTES)
FILRD:
FILRD0: LXI D, BUFF
FILRD1: PUSH D
MVI C, 26
CALL BDOS
LXI D, FCB2
MVI C, 20
CALL BDOS
POP D
PUSH PSW
LXI H, 80H
DAD D
XCHG
POP PSW
CPI 0
RNZ
JMP FILRD1

;ROUTINE TO ECHO FILE RECORD DATA TO CONSOLE
;-FIRST FILE RECORD (BUFF) CONTAINS "DATA1" (ASCII),
;START CHAN (HEX), FINAL CHAN (HEX), NUMBER DATA POINTS$
;SCAN RATE$RUN CONTROL NUMBER$ (ALL IN ASCII)
0703 118008    LXI D, BUFF
0706 D5        PUSH D
0707 0E1A      MVI C, 26
0709 CD0500    CALL BDOS
070C 117D05    LXI D, FCB2
070F 0E14      MVI C, 20
0711 CD0500    CALL BDOS
0714 D1        POP D
0715 F5        PUSH PSW
0716 218000    LXI H, 80H
0719 19        DAD D
071A EB        XCHG
071B F1        POP PSW
071C FE00      CPI 0
071E C0        RNZ
071F C30607    JMP FILRD1

```

```

;BUFF+20H CONTAINS UPPER MEMORY LIMIT OF DATA --
;BUFF+30H CONTAINS SCAN WORD LENGTH (EFFECTIVE
;LINE LENGTH FOR TRANSMISSION TO CMS)
;
ECHO:
0722 CDC706      CALL      CRLF
0725 118008      LXI      D,      BUFF
0728 0605        MVI      B,      6H
;SKIP LINE
;FIRST LINE OF FILE

ELOOP:
072A 1A          LDAX     D
072B CDCA04      CALL     CONOUT
072E 13          INX     D
072F 05          DCR     B
0730 C22A07      JNZ     ELOOP
0733 CDC706      CALL     CRLF
0736 118708      LXI      D,      BUFF+8H
0739 CDF806      CALL     MESS2
073C D5          PUSH     D
073D 111803      LXI      D,      MSG9
0740 CDF206      CALL     MESSAGE
0743 D1          POP      D
0744 CDF806      CALL     MESS2
0747 D5          PUSH     D
0748 114B03      LXI      D,      MSG11
074B CDF206      CALL     MESSAGE
074E 115F03      LXI      D,      MSG12
0751 CDF206      CALL     MESSAGE
0754 D1          POP      D
0755 CDF806      CALL     MESS2
0758 CDC706      CALL     CRLF
075B CDC706      CALL     CRLF
075E C9          RET
;
;SETS UP CMS TO RECEIVE FILE BY COMMANDING
; "EDIT FILENAME FILETYPE"
;
CMS:

```

075F 11D402	CMS2:	LXI	D,	MSG5
0762 1A		LDAX	D	
0763 FE24		CPI	'\$'	
0765 CA7207		JZ	CMS3	
0768 CDCA04		CALL	CONOUT	
076B CD0205		CALL	SEND	
076E 13		INX	D	
076F C36207		JMP	CMS2	
0772 115808	CMS3:	LXI	D,	BUFF40
0775 1A	CMS4:	LDAX	D	
0776 FE24		CPI	'\$'	
0778 CA8507		JZ	CMS5	
077B CDCA04		CALL	CONOUT	
077E CD0205		CALL	SEND	
0781 13		INX	D	
0782 C37507		JMP	CMS4	
0785 3E13	CMS5:	MVI	A,	XOFF
0787 CD0205		CALL	SEND	
078A C9		RET		
078B DB61		IN	61H	
078D E602		ANI	2	
078F CA8B07		JZ	ANS	
0792 DB60		IN	60H	
0794 FE11		CPI	XON	
0796 C8		RZ		
0797 FE13		CPI	XOFF	
0799 CA8B07		JZ	ANS	
079C CDCA04		CALL	CONOUT	
079F C38B07		JMP	ANS	

;FILTERS OUT XOFF

;RECEIVES CMS ANSWERS AND ECHOES TO CONSOLE



```

07A2 DB61
37A4 E602
07A6 CAA207
07A9 DB60
07AB FE11
07AD C8
07AE FE13
07B0 CAA207
07B3 FE0D
07B5 CAA207
07B8 FE0A
07BA CAA207
07BD FE3E
07BF CAA207
07C2 CDCA04
07C5 C3A207

;FILTERS OUT XOFF,CR,LF,AND >
ANS2:
IN 61H
ANI 2
JZ ANS2
IN 60H
CPI XON
RZ
CPI XOFF
JZ ANS2
CPI CR
JZ ANS2
CPI LF
JZ ANS2
CPI '>'
JZ ANS2
CALL CONOUT
JMP ANS2

;TRANSMITS FILE TO CMS
XMIT:
LXI D,MSG6
CALL MESSAGE
CALL PAUSE
LXI D,BUFF+80H
LDA BUFF+30H
MOV H,A
XMIT2:
LDAX D
CALL ASCII
MOV A,B
CALL SEND
MOV A,C
CALL SEND
DCR H
JZ ENDLN2

;PROMPTS "TRANSMITTING"
; DELAY 100 MICROSECS AT BEGIN-
;NING OF EACH LINE
;NUMBER CHAR PER LINESCAN

```

07E8 13	SKIP:	INX	D		
07E9 CD0908		CALL	BREAK3		
07EC C3D807		JMP	XMIT2		
07EF 11FB02	XMIT3:	LXI	MSG7		; PROMPTS "TRANSMISSION COMPLETE"
07F2 CDF206		CALL	MESSAGE		
07F5 3E13	XMIT35:	MVI	A,	XOFF	; SENDS DOUBLE XOFF TO SHIFT
07F7 CD0205		CALL	SEND		; CMS FROM INPUT TO EDIT MODE
07FA C9		RET			; WAIT FOR ANSWER AND DELAY
		; ROUTINE CONVERTS HEX BYTE TO TWO ASCII CHARS			
	ASCII:	PUSH	PSW		
07FB F5		RRC			
07FC 0F		RRC			
07FD 0F		RRC			
07FE 0F		RRC			
07FF 0F		RRC			
0800 CD0EFE		CALL	CONV	C	; SAVES ONE IN B REG
0803 41		MOV	B,		
0804 F1		POP	PSW		
0805 CD0EFE		CALL	CONV		; OTHER RETURNED IN C REG
0808 C9		RET			
		; BREAK3:			
0809 DBF7		IN	0F7H		
080B E602		ANI	2		
080D C8		RZ			
080E DBF6		IN	0F6H		
0810 E67F		ANI	7FH		
0812 FE04		CPI	CNTLD		
0814 C0		RNZ			
0815 C3BC06		JMP	DIRECT		
	ENDLN2:				
0818 3E13		MVI	A,	XOFF	
081A CD0205		CALL	SEND		

081D CDA207	CALL	ANS2	
0820 CD3108	CALL	PAUSE	
0823 3AA008	LDA	BUFF+20H	
0826 BA	CMF	D	
0827 CAEF07	JZ	XMIT3	
082A 3AB008	LDA	BUFF+30H	
082D 67	MOV	H, A	
082E C3E807	JMP	SKIP	
			;CONTINUE TRANSMITTING
			;DELAY APPROX 100 MICROSECONDS
0831 210002	LXI	H, 200H	
			PAUSE2:
0834 2B	DCX	H	
0835 7C	MOV	A, H	
0836 FE00	CPI	0	
0838 C23408	JNZ	PAUSE2	
083B C9	RET		
			;COMMANDS CMS TO "FILE" TRANSMITTED DATA
			FILE:
083C CD3108	CALL	PAUSE	
083F 111303	LXI	D, MSG8	
			FILE2:
0842 1A	LDAX	D	
0843 FE24	CPI	'\$'	
0845 CA5208	JZ	FILE3	
0848 CDCA04	CALL	CONOUT	
084B CD0205	CALL	SEND	
084E 13	INX	D	
084F C34208	JMP	FILE2	
			FILE3:
0852 3E13	MVI	A, XOFF	
0854 CD0205	CALL	SEND	
0857 C9	RET		
			DS 20
BUFF40:			DS 2

MODEL 40 PRINT PROGRAM

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```

INDEX:      DS
MODE:       DS
NEAT:       DS
SKNDEX:     DS
TEXT:       DS
TYTLE:     DS
STACK:     DS
STKBTM EQU 64 $

;LINE SPACER INDEX
;ALL OR PARTIAL MODE INDEX
;INDEX FOR BLANKING FIRST LINE
;LINE SKIP INDEX
;1 IF TEXT FILE
;TITLE WILL BE STORED HERE
;RESERVE STACK SPACE
1 1
2 1
1 1
12 1
64 $

;MESSAGES
MSG15: DB
MSG2: DB
MSG3: DB
MSG4: DB
MSG7: DB
MSG8: DB
MSG9: DB
MSG10: DB
MSG13: DB
MSG14: DB

'TEXT FILE?? (Y/N) $'
'TYPE 2 FOR DOUBLE SPACE $'
'(DEFAULT = SINGLE SPACE) $'
'FILE NOT FOUND $'
'CHECK FOR ERRORS IN CURRENT RECORD $'
'HAVE A NICE DAY $'
'DONE $'
'TYPE K TO CANCEL OR SPACE TO CONTINUE $'
'PRINT ALL (A) OR PART (P) ?? $'
'ENTER STRING1,STRING2 -- (LIMIT 15 CHARACTERS EACH) $'

;MAIN PROGRAM
MAIN: LXI SP, STKBTM
CALL BOARD
MVI A, 0H
STA MODE
STA TEXT
STA LCOUNT
;OPEN DISK FILE FOR READING
SETUP: LXI D, FCB
MVI C, OPENF
CALL BDOS
;CHECK FOR ERRORS
0272 315D01
0275 CDF605
0278 3E00
027A 320C01
027D 321001
0280 320701

0283 115C00
0286 0E0F
0288 CD0500

```



028B FEFF	CPI	255	
028D CA6C03	JZ	BADF	
	;GOOD OPEN		
0290 AF	XRA	A	
0291 327C00	STA	FCBCR	
0294 CDCF04	CALL	CRLF	
0297 116401	LXI	D,	MSG15
029A CDED04	CALL	CRTMSG	
029D 0E01	MVI	C,	READC
029F CD0500	CALL	BDOS	
02A2 321001	STA	TEXT	
02A5 FE59	CPI	'Y'	
02A7 CA1403	JZ	FILERD-3	
02AA CDCF04	CALL	CRLF	
02AD 117801	LXI	D,	MSG2
02B0 CDED04	CALL	CRTMSG	
02B3 CDCF04	CALL	CRLF	
02B6 119101	LXI	D,	MSG3
02B9 CDED04	CALL	CRTMSG	
02BC 0E01	MVI	C,	READC
02BE CD0500	CALL	BDOS	
02C1 FE32	CPI	32H	
02C3 CAD302	JZ	DBL	55
02C6 3E37	MVI	A,	
02C8 320B01	STA	LNDEX	6
02CB 3E06	MVI	A,	
02CD 320F01	STA	SKNDEX	
02D0 C3DD02	JMP	BEGIN	
DBL:			
02D3 3E1C	MVI	A,	28
02D5 320B01	STA	LNDEX	
02D8 3E03	MVI	A,	3
02DA 320F01	STA	SKNDEX	

02DD AF	XRA	A	
02DE 320701	STA	ICOUNT	
02E1 320901	STA	PCOUNT	
02E4 320A01	STA	PCOUNT+1	
	; DETERMINE PRINT MODE - ALL OR PARTIAL		
02E7 CDCF04	CALL	CRLF	
02EA 111F02	LXI	D,	MSG13
02ED CDED04	CALL	CRMSG	
02F0 CDDA04	CALL	RDMSG	
02F3 FE50	CPI	'P'	
02F5 CC3505	CZ	PART	
	; READ FIRST RECORD		
02F8 3A6800	LDA	FCBRL	
02FB F5	PUSH	PSW	
02FC 3E24	MVI	A,	'\$'
02FE 326800	STA	FCBRL	
0301 115D00	LXI	D,	FCBFL
0304 211101	LXI	H,	TYTLE
0307 1A	TITLOOP:		
	LDAX	D	
0308 77	MOV	M,	A
0309 23	INX	H	
030A 13	INX	D	
030B FE24	CPI	'\$'	
030D C20703	JNZ	TITLOOP	
0310 F1	POP	PSW	
0311 326800	STA	FCBRL	
0314 11010A	LXI	D,	0A01H
	FILRD:		
	PUSH	D	
0318 0E1A	MVI	C,	26
031A CD0500	CALL	BDOS	
	; CHANGE DMA BUFFER ADDRESS		

031D 115C00	LXI	D,	FCB	
0320 0E14	MVI	C,	READFR	
0322 CD0500	CALL	BDOS		;READ FILE RECORD
0325 D1	POP	D		
0326 F5	PUSH	PSW		
0327 218000	LXI	H,	80H	
032A 19	DAD	D		
032B EB	XCHG			
032C F1	POP	PSW		;CHECK FOR ERRORS
032D FE00	CPI	0		
032F CA1703	JZ	FILERD		
0332 FE01	CPI	01		
0334 C4AA04	CNZ	ERROR		;CHECK FOR END OF FILE
0337 3A0C01	LDA	MODE		
033A FE2A	CPI	'*'		
033C CA7105	JZ	FIND		
033F 21000A	LXI	H,	0A00H	
0342 C34903	JMP	NEWPG		
REDY:				
0345 2A0301	LHLD	LIMIT1		
0348 2B	DCX	H		
;ROUTINE STARTS NEW PAGE				
NEWPG:				
0349 CDF203	CALL	PLABEL		
;ROUTINE BEGINS NEW LINE				
NEWLN:				
034C 3E00	MVI	A,	0	
034E 320801	STA	CCOUNT		
0351 3A0C01	LDA	MODE		
0354 FE2A	CPI	'*'		;DETERMINE IF IN PARTIAL MODE
0356 CCC903	CZ	CLEAN		
GUTS:				
0359 CD7203	CALL	GNB		;STARTS MAIN LOOP

```

035C FE0D      CR      ENDLN
035E CA9103    JZ
0361 FE09      CPI     TB
0363 CADC03    JZ      TAB
0366 CD7A03    CALL    PRCHAR
0369 C35903    JMP      GUTS
                ;END OF MAIN PROGRAM
*****
;SUBROUTINES
;BAD OPEN
BADF:          MVI      B, 01
               CALL    ERROR
               RET
               GNB:
036C 0601
036E CDAA04
0371 C9
0372 23
0373 7E
0374 FE1A
0376 CA0005
0379 C9
               INX
               MOV     A, M
               CPI     1AH
               JZ      DONE
               RET
               ;MAINTAINS CHARACTER COUNT
PRCHAR:        CALL    DRIVER
               LDA      CCOUNT
               INR      A
               STA      CCOUNT
               CPI     115
               RNZ
               ; 115 CHARACTERS PER LINE
037A CD7C04
037D 3A0801
0380 3C
0381 320801
0384 FE73
0386 C0
0387 CD7203
038A FE0D
038C CA9103
               TRUNC:
               CALL    GNB
               CPI     CR
               JZ      ENDLN

```

038F 3E0D

MVI A, CR

;FINISHES LINE AND CHECKS LINE COUNT  
ENDLN:

0391 CD7C04  
0394 CD7203  
0397 FE0A  
0399 CA9E03  
039C 3E0A

CALL DRIVER  
CALL GNB  
CPI LF  
JZ THERE  
MVI A, LF

THERE:

039E CD7C04  
03A1 CD8704  
03A4 3A1001  
03A7 FE59  
03A9 CA4C03  
03AC 3A0701  
03AF 3C  
03B0 320701  
03B3 E5  
03B4 210B01  
03B7 BE  
03B8 E1  
03B9 C24C03

CALL DRIVER  
CALL BREAK  
LDA TEXT  
CPI 'Y'  
JZ NEWLN  
LDA LCOUNT  
INR A  
STA LCOUNT  
PUSH H  
LXI H, INDEX  
CMP M  
POP H  
JNZ NEWLN

;OUTPUT FORMFEED TO PRINTER; IF OUT OF PAPER CONDITION  
;EXISTS, RECEIPT OF FF TURNS PRINTER OFF. WHEN IN PARTIAL  
;PRINT MODE, THIS SPACES FIRST LINE TO ALIGN DESIRED FIRST  
;WORD IN PROPER COLUMN

03E3 3E0C  
03E5 CDA304  
03E8 3E00  
03EA 320701  
03EC C34903

MVI A, FF  
CALL DRIVER  
MVI A, 0  
STA LCOUNT  
JMP NEWPG

CLEAN:



03C9 3A0D01	LDA	NEAT	A
03CC 47	MOV	B,	
SWEEP:			
03CD 3E20	MVI	A,	20H
03CF CD7A03	CALL	PRCHAR	
03D2 05	DCR	B	
03D3 C2CD03	JNZ	SWEEP	0
03D6 3E00	MVI	A,	
03D8 320C01	STA	MODE	
03DB C9	RET		

;SKIPS SPACES TO NEXT TAB SETTING  
TAB:

03DC 3A0801	LDA	CCOUNT	A
03DF 47	MOV	B,	
03E0 E6F8	ANI	0F8H	
03E2 C608	ADI	08H	
03E4 90	SUB	B	
03E5 47	MOV	B,	A

TBLOOP:			
03E6 3E20	MVI	A,	20H
03E8 CD7A03	CALL	PRCHAR	
03EB 05	DCR	B	
03EC C2E603	JNZ	TBLOOP	
03EF C35903	JMP	GUTS	

; INCREMENTS PAGE NUMBER IN BCD  
PLABEL:

03F2 3A1001	LDA	TEXT	
03F5 FE59	CPI	'Y	
03F7 C8	RZ		
03F8 E5	PUSH	H	
03F9 3A0F01	LDA	SKNDEX	

PGLOOP:

03FC 47	MOV	B,	A	
03FD 3E0A	MVI	A,	LF	
03FF CD7C04	CALL	DRIVER		
0402 05	DCR	B		
0403 C2FD03	JNZ	PGLOOP+1		
0406 115D01	LXI	D,	MSG1	
0409 CDF504	CALL	PRMSG		
040C 1600	MVI	D,	0	
040E 210901	LXI	H,	PCOUNT	
0411 7E	MOV	A,	M	
0412 3C	INR	A		
0413 27	DAA			
0414 77	MOV	M,	A	
0415 23	INX	H		
0416 7E	MOV	A,	M	
0417 CE00	ACI	0		
0419 77	MOV	M,	A	
041A E6F0	ANI	0F0H		
041C 1F	RAR			
041D 1F	RAR			
041E 1F	RAR			
041F 1F	RAR			
0420 CD5104	CALL	PRPAGE		
0423 7E	MOV	A,	M	
0424 E60F	ANI	0FH		
0426 CD5104	CALL	PRPAGE		
0429 2B	DCX	H		
042A 7E	MOV	A,	M	
042B E6F0	ANI	0F0H		
042D 1F	RAR			
042E 1F	RAR			
042F 1F	RAR			
0430 1F	RAR			
0431 CD5104	CALL	PRPAGE		
0434 7E	MOV	A,	M	
0435 E60F	ANI	0FH		

0437	CD5104	CALL	PRPAGE	30
043A	361E	MVI	B,	
LOOPER:				
043C	3E20	MVI	A,	20H
043E	CD7C04	CALL	DRIVER	
0441	05	DCR	B	
0442	C23C04	JNZ	LOOPER	
0445	211101	LXI	H,	TYTLE
0448	EB	XCHG		
0449	CD504	CALL	PRMSG	
044C	CD6404	CALL	PCR2LF	
044F	E1	POP	H	
0450	C9	RET		

;PRINTS PAGE NUMBER DIGIT  
PRPAGE:

0451	C630	ADI	30H	
0453	FE30	CPI	30H	
0455	C25E04	JNZ	PRPG	
0458	47	MOV	B,	A
0459	7A	MOV	A,	D
045A	FE01	CPI	01	
045C	C0	RNZ		
045D	78	MOV	A,	B

PRPG:

045E	1601	MVI	D,	01
0460	CD7C04	CALL	DRIVER	
0463	C9	RET		

;PRINTER FORMAT CONTROL  
PCR2LF:

0464	3E0D	MVI	A,	CR
0466	CD7C04	CALL	DRIVER	
0469	3E0A	MVI	A,	LF
046B	CD7C04	CALL	DRIVER	
046E	3E0A	MVI	A,	LF
0470	CD7C04	CALL	DRIVER	

0473 3A0701  
0476 C603  
0478 320701  
047B C9

LDA LCOUNT  
ADI 03  
STA LCOUNT  
RET

047C F5

PUSH PSW

STS:

047D DB63  
047F 0F  
0480 D27D04  
0483 F1  
0484 D362  
0486 C9

IN 63H  
RRC  
JNC STS  
POP PSW  
OUT 62H  
RET

;CHECKS STATUS AND XMITTS DATA TO USART

DRIVER:

;CHECK BREAK KEY (ANY KEY) FOR INTERRUPT

BREAK:

0487 0E0B  
0489 E5  
048A CD0500  
048D E1  
048E 0F  
048F D0  
0490 E5  
0491 CDCF04  
0494 11F801  
0497 CDED04  
049A CDCF04  
049D CDDA04  
04A0 CDDA04  
04A3 FE4B  
04A5 E1  
04A6 C0  
04A7 C30005

MVI C, .BRKF  
PUSH H  
CALL BDOS  
POP H  
RRC  
RNC  
PUSH H  
CALL CRLF  
LXI D, MSG10  
CALL CRTMSG  
CALL CRLF  
CALL RDMSG  
CALL RDMSG  
CALL 'K'  
CPI H  
POP RNZ  
JMP DONE

;EMPTY UART BUFFER  
;WAIT FOR NEXT CHAR

;PRINT ERROR MESSAGE ON CONSOLE  
ERROR:

04AA E5  
04AB CDCF04  
04AE 3E07  
04B0 CDE204  
04B3 78  
04B4 FE01  
04B6 CABE04  
04B9 FE03  
04BB CAC704

PUSH H  
CALL CRLF  
MVI A, 07  
CALL WRMSG  
MOV A, B  
CPI 01  
JZ ERR1  
CPI 03  
JZ ERR3

ERR1:

04BE 11AB01  
04C1 CDED04  
04C4 C30005

LXI D, MSG4  
CALL CRTMSG  
JMP DONE

;FILE NOT FOUND

ERR3:

04C7 11BB01  
04CA CDED04  
04CD E1  
04CE C9

LXI D, MSG7  
CALL CRTMSG  
POP H  
RET

;CARRIAGE RETURN AND LINE FEED

CRLF:

04CF 3E0D  
04D1 CDE204  
04D4 3E0A  
04D6 CDE204  
04D9 C9

MVI A, CR  
CALL WRMSG  
MVI A, LF  
CALL WRMSG  
RET

;READ CHARACTER FROM CONSOLE

RDMSG:

04DA 0E01

MVI C, READC



04DC D5	PUSH D	
04DD CD0500	CALL BDOS	
04E0 D1	POP D	
04E1 C9	RET	
;WRITE CHARACTER TO CONSOLE		
	WRMSG:	
04E2 C5	PUSH B	
04E3 D5	PUSH D	
04E4 0E02	MVI C, TYPEC	
04E6 5F	MOV E, A	
04E7 CD0500	CALL BDOS	
04EA D1	POP D	
04EB C1	POP B	
04EC C9	RET	
;PRINTS MESSAGE ON CONSOLE		
	CRMSG:	
04ED 0E09	MVI C, 9	
04EF E5	PUSH H	
04F0 CD0500	CALL BDOS	
04F3 E1	POP H	
04F4 C9	RET	
;PRINTS MESSAGE ON PRINTER		
	PRMSG:	
04F5 1A	LDAX D	
04F6 FE24	CPI '\$'	
04F8 C6	RZ	
04F9 CD7C04	CALL DRIVER	
04FC 13	INX D	
04FD C3F504	JMP PRMSG	
;SIGN OFF ON PRINTER		
	DONE:	
0500 CD6404	CALL PCR2LF	
0503 3A0B01	LDA LINDEX	

0506 D603	SUI	3H	
0508 2A0701	LHLD	LCOUNT	
050B BE	CMP	M	
050C FA1D05	JM	FINISH	
050F 3A1001	LDA	TEXT	
0512 FE59	CPI	'Y'	
0514 CA1D05	JZ	FINISH	MSG8
0517 11DF01	LXI	D,	
051A CDF504	CALL	PRMSG	
	FINISH:		
051D CD6404	CALL	PCR2LF	
0520 3E0C	MVI	A,	FF
0522 CD7C04	CALL	DRIVER	
0525 3E50	MVI	A,	50H
0527 D363	OUT	063H	
0529 CDCF04	CALL	CRLF	
052C 11F201	LXI	D,	MSG9
052F CDED04	CALL	CRTMSG	
0532 C30000	JMP	0000H	

;SET UP TO PRINT PART OF PROGRAM  
PART:

0535 CDCF04	CALL	CRLF	
0538 3E2A	MVI	A,	'*'
053A 320C01	STA	MODE	
053D 113D02	LXI	D,	MSG14
0540 CDED04	CALL	CRTMSG	
0543 CDCF04	CALL	CRLF	
0546 110009	LXI	D,	900H

;READ AND STORE STRING CHARACTERS-  
STR1:

0549 13	INX	D	
054A CDDA04	CALL	RDMSG	
			;STRING1 BEGINS AT 901H
			;STRING2 BEGINS AT 911H

```

054D FE7F      CPI
054F CAE405    JZ
0552 12        STAX
0553 FE2C      CPI
0555 C24905    JNZ
0558 3E13      MVI
055A 12        STAX
055B 111009    LXI

                7FH
                UNDO1
                D,
                ,
                STR1
                A,
                D,
                D,
                13H
                910H

STR2:
055E 13        INX
055F CDDA04    CALL
0562 FE7F      CPI
0564 CAED05    JZ
0567 12        STAX
0568 FE0D      CPI
056A C25E05    JNZ
056D 3E13      MVI
056F 12        STAX
0570 C9        RET

                D
                RDMSG
                7FH
                UNDO2
                D
                CR
                STR2
                A,
                D,
                13H

FIND:
0571 21010A    LXI
0574 220301    SHLD
0577 2B        DCX

                H,
                LIMIT1
                H

                0A01H      ;FIND 1ST STRING AND APPEND ALL

RESET:
0578 110109    LXI
057B 1A        LDAX
057C FE13      CPI
057E CAB205    JZ

                D,
                D,
                13H
                FIND28

                901H      ;AFTER TO TPA STARTING AT 0A01

;LOCATE 1ST CHARACTER OF 1ST STRING
FIND1:
0581 23        INX
0582 BE        CMP

```

0583 C28105	JNZ	FIND1	
0586 220301	SHLD	LIMIT1	
;AFTER 1ST CHARACTER FOUND, CHECK ADDITIONAL CHARACTERS			
;UNTIL STRING IS EXHAUSTED			
NCR:			
05A8 13	INX	D	
05A9 23	INX	H	
058B 1A	LDAX	D	
058C FE13	CPI	13H	
058E CA9E05	JZ	FIND2	
0591 BE	CMP	M	
0592 C29805	JNZ	FIND15	
;IF NOT CORRECT STRING			
;BEGIN SEARCH AGAIN			
0595 C38905	JMP	NCR	
FIND15:			
0598 2A0301	LHLD	LIMIT1	
059B C37805	JMP	RESET	
FIND2:			
059E E5	PUSH	H	
059F 2A0301	LHLD	LIMIT1	
05A2 5D	MOV	E,	L
05A3 3E0A	MVI	A,	LF
;SET UP SPACING FOR 1ST LINE-			
;DESIRE FIRST WORD TO PRINT IN			
;PROPER COLUMN			
FORMAT:			
05A5 2B	DCX	H	
05A6 BE	CMP	M	
05A7 C2A505	JNZ	FORMAT	E
05AA 7B	MOV	A,	
05AB 95	SUB	L	
05AC D601	SUI	1	
05AE 320D01	STA	NEAT	
05B1 F1	POP	H	

05B2 111109	LDI	D,	911H	
	FIND28:			
	;SEARCH FOR 1ST CHARACTER OF 2ND STRING			
05B5 1A	LDAX	D		
05B6 FE13	CPI	13H		
05B8 CA4503	JZ	REDY		
05BB BE	CMP	M		
05BC 23	INX	H		
05BD C2BB05	JNZ	FIND3+6		
05C0 2B	DCX	H		
05C1 220501	SHLD	LIMIT2		
				;SAVE ADDRESS IN CASE THIS IS
05C4 23	INX	H		;CORRECT STRING
05C5 13	INX	D		
05C6 1A	LDAX	D		
05C7 FE13	CPI	13H		
05C9 CADB05	JZ	FOUND		
05CC BE	CMP	M		
05CD 23	INX	H		
05CE C2D405	JNZ	FIND25		
05D1 C3C505	JMP	NCR2		
				FIND25:
05D4 2A0501	LHLD	LIMIT2		
05D7 23	INX	H		
05D8 C3B205	JMP	FIND26		
05DB 2A0501	LHLD	LIMIT2		
05DE 3E1A	MVI	A,	1AH	
05E0 77	MOV	M,	A	
05E1 C34503	JMP	REDY		
				;USE CHARACTER 1AH AS DELIMITER
				;TO APPENDED MEMORY DATA



```

05E4 1B          DCX      D
05E5 1A          LDAX     D
05E6 CDE204      CALL     WRMSG
05E9 1B          DCX      D
05EA C34905      JMP      STR1

UND02:
05ED 1B          DCX      D
05EE 1A          LDAX     D
05EF CDE204      CALL     WRMSG
05F2 1B          DCX      D
05F3 C35E05      JMP      STR2

```

# BOARD:

THIS ROUTINE INITIALIZES THE 534 BOARD, THE TIMERS, AND THE TWO USARTS  
NEEDED TO DRIVE THE IBM HIGH SPEED LINE AND THE MODEL 40 PRINTER

```

BASE ADDR OF 534 BOARD      60H
CMD ADDR OF LINE USART      61H
DATA ADDR OF LINE USART     62H
CMD ADDR OF PTR USART       63H
DATA ADDR OF PTR USART      62H

```

TWO MORE USARTS AND ONE 8255 PARALLEL INTERFACE AND THEIR TIMERS ARE  
AVAILABLE ON THE 534 BOARD. NEW INTERFACES MUST BE PROGRAMMED BEFORE USE

```

05F6 F3          DI      6FH
05F7 D36F        OUT     6CH
05F9 D36C        OUT     TIMER
05FB CD0306      CALL

```

```

;DISABLES 8080 INTERRUPTS
;RESETS BOARD
;SELECTS BOARD CONTROL BLOCK
;INITIALIZE PIT CHIPS

```

```

05FE CD1406
0601 FB
0602 C9

;
;
;
; MUST SET UP TIMER CHIPS ACCORDING TO PAGE 3-12 OF 534 MANUAL
; CHIP 0 HAS THREE TIMERS ON IT
; TIMERS 0 AND 1 OF CHIP 0 ARE CONNECTED TO USARTS 1 AND 2
; RESPECTIVELY, DRIVING THE IBM LINE AND THE PRINTER
;

CALL USART
EI
RET

; INITIALIZE USARTS
; REENABLES INTERRUPTS

TIMER:
0603 D36C OUT 6CH
0605 3E76 MVI A, 76H
0607 D363 OUT 63H
0609 3E08 MVI A, 8H
060B D361 OUT 61H
060D 3E00 MVI A, 0H
060F D361 OUT 61H
0611 D36D OUT 6DH
0613 C9 RET

; SELECT CONTROL BLOCK
;
; SELECT TIMER 1 FOR PTR USART
;
; SET N=8 IN TIMER 1
; CCLK/N=153.6KHZ FOR 9600 BAUD,
; BRF=16X
; PUTS BOARD IN DATA BLOCK

```

```

;
;
; SET UP BOTH USARTS WITH RESETS AND MODE WORDS
;

```

```

USART:
0614 3E5A MVI A, 5AH ; 1 STOP, PAR DISABLED, 7 BITS
0616 D363 OUT 63H
0618 3E33 MVI A, 33H
061A D363 OUT 63H
061C C9 RET

```

```

*****

```

# APPENDIX J

## G02 ASSEMBLY PROGRAM

1 AUG 1978

```

**
**MDS 8080 PROGRAM INTERFACES DTEL ST-800 ANALOG
**TO DIGITAL CONVERTER BOARD AND INTEL DYNAMIC
**MEMORY ACCESS CONTROLLER FOR HIGH SPEED DATA
**ACQUISITION ---
**MAXIMUM OF 16 CHANNELS ARE INPUT, CONVERTED,
**AND STORED IN MEMORY AT A RATE OF 40 KHZ ---
**PROGRAMMABLE INTERRUPT CONTROLLER AND
**INTERVAL TIMERS ON THE INTEL SBC 534 BOARD ARE
**INTERFACED TO PROVIDE VARIABLE SCAN RATES
**OF ONE TO 2000 SCANS PER SECOND *****
*****

```

ORG 100H

0100 C39C05

JMP START

;EQUATES

```

CR      EQU      0DH      ;CARRIAGE RETURN
LF      EQU      0AH      ;LINE FEED
BDOS    EQU      5H      ;BDOS ENTRY POINT
DMACMD  EQU      17H      ;DMA COMMAND WORD
REVRT   EQU      20H      ;CPU INTERRUPT CLEAR COMMAND
R04     EQU      20H      ;RESTART 04 ADDRESS
R05     EQU      28H      ;RESTART 05 ADDRESS
DMA     EQU      40H      ;DMA BASE ADDRESS
SBC     EQU      60H      ;SBC 534 BASE ADDRESS
JUMP    EQU      0C3H     ;JUMP INSTRUCTION
MASK    EQU      0FCH     ;MASK ALTERATION PORT

```

```

MEMORY EQU      0A00H      ;DATA MEMORY BUFFER ADDRESS
;
;
; DATA SAVES
;
WCNT: DS        ;WORD LENGTH SETTING ( X 2 )
ACHAN: DS       ;START CHANNEL
BCHAN: DS       ;FINAL CHANNEL
INTVL4: DS      ;TIMER 4 SETTING
INTVL5: DS      ;TIMER 5 SETTING
RCOUNT: DS      ;SCAN RATE REGISTER
PCOUNT: DS      ;# DATA POINTS REGISTER
LIMIT: DS      ;MSB OF UPPER MEMORY LIMIT
FLNAME: DB      ;DATA1 XXX',0,0,0,0
DS 17D
STACK: DS
STKBTM EQU
;
;
; MESSAGES
;
MSG1: DB CR,LF,'ENTER STARTING CHANNEL $'
MSG2: DB CR,LF,'ENTER FINAL CHANNEL $'
MSG3: DB CR,LF,'CARRIAGE RETURN TO BEGIN $'
MSG4: DB CR,LF,'TRY AGAIN, TURKEY $'
MSG5: DB CR,LF,'ENTER DESIRED NUMBER OF DATA POINTS'
      DB CR,LF,LF,'ENTER DATA POINTS'
      DB CR,LF,LF,'A 1024'
      DB CR,LF,LF,'B 4096'
      DB CR,LF,LF,'C 5120'
      DB CR,LF,LF,'D 10240'
      DB CR,LF,LF,'E 26112'
      DB CR,LF,LF,'$'
MSG6: DB CR,LF,'SELECT SCAN RATE',CR,LF,LF
      DB CR,LF,'ENTER SCANS/SEC'
      DB CR,LF,'MAX CHANNELS',CR,LF
      DB CR,LF,'2K'
      DB CR,LF,'4K'
      DB CR,LF,'10K'
      DB CR,LF,'20K'
      DB CR,LF,'52K'
      DB CR,LF,'DISK SPACE'

```

[illegible]



```

05B7 CD4307      CALL      DIGIT1      ACHAN      ;GETS CHANNEL VALUES
05BA 210401      LXI          H,          ;INITIAL CHANNEL VALUE
05BD 3A0501      LDA          BCHAN      ;FINAL CHANNEL VALUE
05C0 96          SUB          M          ;DETERMINE DIFFERENCE
05C1 F2CA05      JP          DIFF
05C4 CDA907      CALL      OOPS          ;FINAL CAN'T BE LESS
05C7 C3B705      JMP          SETUP      ;BACKUP AND TRY AGAIN
;WORD LENGTH IS (DIFFERENCE + 1) X 2
;
;DIFF:
05CA C601      ADI          1H          ;TIMES 2
05CC 17          RAL
05CD 320301      STA          WCNT
;
;
;DETERMINE NUMBER OF DATA POINTS DESIRED
;
LXI      D,      MSG5      ;PROMPT USER
MVI      C,      9H
CALL      BDOS
CALL      KEY
STA      PCOUNT      ;SAVE FOR FUTURE USE
;
;SEE WHICH CHOICE
;
POINT:
05DE FE41      CPI          'A'
05E0 CAFD05      JZ          APOINT
05E3 FE42      CPI          'B'
05E5 CA0206      JZ          BPOINT
05E8 FE43      CPI          'C'
05EA CA0706      JZ          CPOINT
05ED FE44      CPI          'D'
05EF CA0C06      JZ          DPOINT
05F2 FE45      CPI          'E'
05F4 CA1106      JZ          EPOINT
;SEE IF A ENTERED
;SEE IF B ENTERED
;SEE IF C ENTERED
;SEE IF D ENTERED
;SEE IF E ENTERED

```

```

05F7 CDA907          ;NOTHING ELSE IS VALID
05FA C3DE05          ;
                                CALL      OOPS
                                JMP        POINT
                                ;
                                APOINT:  MVI      0EH
                                JMP        DOWN
                                BPOINT:  MVI      1AH
                                JMP        DOWN
                                CPOINT:  MVI      32H
                                JMP        DOWN
                                DPOINT:  MVI      5AH
                                JMP        DOWN
                                EPOINT:  MVI      0D8H
                                DOWN:    STA      LIMIT
                                ;
                                ;LIMIT IS NOW SET UP
                                ;NEXT DETERMINE DESIRED SCAN RATE
                                ;
                                RATE:    ;
                                ;
                                LXI      D,      MSG6
                                MVI      C,      SH
                                CALL      BDOS
                                CALL      KEY
                                LXI      D,      RCOUNT
                                STA      'A
                                CPI      'A
                                JZ        ARATE
                                CPI      'B
                                JZ        BRATE
                                CPI      'C
                                JZ        'C
                                ;
                                ;PROMPT USER
                                ;GET USER'S CHOICE OF RATES
                                ;LOAD D FOR LATER USE
                                ;SAVE FOR FUTURE USE
                                ;SEE IF A ENTERED
                                ;SEE IF B ENTERED
                                ;SEE IF C ENTERED

```



```

067E 21872F      ;
0681 C39336      ;
0684 2104EF      ; NORMALLY THE SETTING IN TIMER 5
0687 110200      ; IS 1, BUT FOR INTERVALS OVER
068A C39306      ; 50 MILLISECONDS, THE COUNT N
                   ; MUST BE DIVIDED BY SOME
                   ; NUMBER M TO REDUCE THE COUNT
                   ; BELOW 0FFFFH; THEN THE TIMER 5
                   ; SETTING INCREASED ACCORDINGLY
068D 21FAEF      ;
0690 111400      ;
                   ; LOAD REGISTERS
0693 220601      ;
0696 EF          ; TIMER 4 SETTING
0697 220801      ;
                   ;
                   ; RATE OF SCAN IS NOW SET INTO EFFECT
                   ;
                   ;
                   ; BEGIN:
                   ;
                   ; NOW READY TO BEGIN SCANNING WHEN PROMPTED
069A 117F01      ;
069D 0E09        ;
069F CD0500      ;
06A2 CDA307      ;
                   ;
                   ;
06A5 110000      ;
06A8 3A0301      ;
06AB 5F          ;
                   ;
                   ; SET UP DMA AND ST-800 BOARDS
                   ;
06AC CDB606      ;
06AF CDED06      ;

```

```

;DMA AND TIMER NOW SET AND RUNNING -
;NOTHING TO DO BUT WAIT
;
WAIT:      XRA      A
          JMP WAIT
;
;END OF MAIN PROGRAM
;
;
;
;
;
;
;SUBROUTINES
;*****
;
;ROUTINE TO INITIALIZE AND RESET DMA AND ST-800
;BOARDS -
;ST-800 IS ADDRESSED VIA DMA BOARD
;DMA IS SET UP TO GENERATE A LEVEL 4 INTERRUPT
;WHENEVER ONE SCAN IS COMPLETED -
;*****ADDRESS LISTING FOLLOWS*****
;DMA BASE ADDR      40H
;OUTPORT0/INPORT0    40H
;OUTPORT1/INPORT1    41H
;OUTPORT2            42H
;DMA STATUS          46H
;DMA RESET           49H
;DMA COMMAND         4AH
;LENGTH REGISTER (LSB) 4CH
;LENGTH REGISTER (MSB) 4DH
;MEMORY ADDR REG (LSB) 4EH
;MEMORY ADDR REG (MSB) 4FH
;

```

06B2 AF  
06B3 C3B2J6



```

06B6 D349
06B8 3A0301
06BB D34C
06BD AF
06BE D34D
06C0 21000A
06C3 7D
06C4 D34E
06C6 7C
06C7 D34F
06C9 3A0401
06CC D340
06CE 3A0501
06D1 D341
06D3 3E17
06D5 D34A
06D7 FB
06D8 C9

;
;
; DMASET:
OUT DMA+9H
LDA WCNT
OUT DMA+0CH
XRA A
OUT DMA+0DH
LXI H, MEMORY
MOV A, L
OUT DMA+0EH
MOV A, H
OUT DMA+0FH
LDA ACHAN
OUT DMA
LDA BCHAN
OUT DMA+1H
MVI A, DMACMD
OUT DMA+0AH
EI
RET

; DMA NOW READY TO GO WHEN COMMAND WORD IS ISSUED
;
; RESET4:
OUT DMA+9H
LDA WCNT
OUT DMA+0CH
XRA A
OUT DMA+0DH
MVI A, REVRT
OUT 0FDH
MVI A, DMACMD
OUT DMA+0AH
EI
RET

06D9 D349
06DB 3A0301
06DE D34C
06E0 AF
06E1 D34D
06E3 3E20
06E5 D3FD
06E7 3E17
06E9 D34A
06EB FB
06EC C9

; RESET DMA
; LSB OF LENGTH REG
; MSB IS ZERO
; LSB OF MEMORY ADDR
; MSB OF MEMORY ADDR
; STARTING CHANNEL
; FINAL CHANNEL
; ENABLES INTERRUPT, 8
; BIT XFER TO MEMORY
; ENABLE INTERRUPTS

; RESET DMA
; LENGTH REG SETTING
; MSB OF LENGTH REG IS 0
; CLEARS INT 4 FROM CPU
; INTERRUPT PENDING STACK
; COMMAND BYTE
; REENABLES INTERRUPTS
; DMA IS READY TO GO

```



```

0705 3A0901      LDA      INTVL5+1      ;MSB OF TIMER 5 COUNT
0708 D366        OUT
070A 3E76        MVI      A, 76H        ;SELECT TIMER 4 AS CLOCK
070C D367        OUT      SBC+7H        ;FOR TIMER 5
070E 3A0601      LDA      INTVL4        ;LSB OF TIMER 4 COUNT
0711 D365        OUT      SBC+5H
0713 3A0701      LDA      INTVL4+1      ;MSB OF TIMER 4 COUNT
0716 D365        OUT      SBC+05H

;
; INTERRUPT TIMER IS NOW SET AND RUNNING
;
0718 D342        OUT      DMA+2H        ;DMA "GO" INSTRUCTION

;
; DMA IS NOW SET AND RUNNING
;
071A C9          RET

;
; ROUTINE TO SERVICE INTERRUPT 5 FROM INTERRUPT TIMER
;
RESET5:
071B 3E76        MVI      A, 76H        ;STOPS TIMER 4
071D D367        OUT      SBC+7H
071F 3A0801      LDA      INTVL5        ;RESET LSB OF TIMER 5
0722 D366        OUT      SBC+6H        ;(REMOVES INT 4 FROM BUS)
0724 3A0901      LDA      INTVL5+1      ;RESET MSB OF TIMER 5
0727 D366        OUT      SBC+6H
0729 3E20        MVI      A, REVRT      ;RESETS CPU
072B D3FD        OUT      0FDH        ;REENABLES INTERRUPTS
072D FB          EI

;
; NEED TO KEEP TRACK OF MEMORY AREA USED TO PREVENT OVER
; RUNNING LIMIT
;
072E 19          DAD      D            ;DE REG CONTAINS WORDLENGTH

```

072F 3A0C01	LDA	LIMIT	
0732 BC	CMP	H	
0733 CAB207	JZ	DONE	;EXIT PROGRAM
			; IF MEMORY SPACE OKAY, RESET TIMER AND CONTINUE
			;
0736 3A0601	LDA	INTVL4	;RESET LSB OF TIMER 4
0739 D365	OUT	SBC+5H	
073B 3A0701	LDA	INTVL4+1	;RESET MSB OF TIMER 4
073E D365	OUT	SBC+5H	
			; INTERRUPT TIMERS RUNNING AGAIN
			;
0740 D342	OUT	DMA+2H	
			; DMA RUNNING AGAIN
			;
0742 C9	RET		
			; ROUTINE TO READ IN INITIAL AND FINAL CHANNELS
			;
			DIGIT1:
0743 114E01	LXI	D,	MSG1
0746 0E09	MVI	C,	9
0748 CD0500	CALL	BDOS	;PROMPT USER
074B CDA307	CALL	KEY	;GET ENTERED CHARACTER
074E FE0D	CPI	CR	
0750 CA4307	JZ	DIGIT1	
0753 D630	SUI	30H	;REDUCE ASCII
0755 320401	STA	ACHAN	
0758 CDA307	CALL	KEY	;SEE IF SECOND CHAR
075B FE0D	CPI	CR	
075D CA7507	JZ	DIGIT2	

```

0760 D630      SUI    30H          ;REDUCE ASCII
0762 C61A     ADI    1AH          ;CONVERT TO HEX
0764 320401   STA    ACHAN        ;STILL NEED CR
0767 CDA307   CALL   KEY          ;TOO MANY CHARACTERS
076A FE0D     CPI    CR           ;TRY AGAIN
076C CA7507   JZ     DIGIT2
076F CDA907   CALL   OOPS         ;TOO MANY CHARACTERS
0772 C34307   JMP    DIGIT1      ;TRY AGAIN

;
;
; DIGIT2:
0775 116801   LXI    D, MSG2
0778 0E09     MVI    C, 9
077A CD0500   CALL   BDOS
077D CDA307   CALL   KEY
0780 FE0D     CPI    CR           ;CR NOT ALLOWED YET
0782 CA7507   JZ     DIGIT2
0785 D630     SUI    30H
0787 320501   STA    BCHAN
078A CDA307   CALL   KEY
078D FE0D     CPI    CR           ;GET NEXT CHAR
078F C8       RZ                ;FINISHED IF CR
0790 D630     SUI    30H
0792 C61A     ADI    1AH          ;CONVERT TO HEX
0794 320501   STA    BCHAN
0797 CDA307   CALL   KEY
079A FE0D     CPI    CR           ;FINISHED IF CR
079C C8       RZ                ;TOO MANY CHARACTERS
079D CDA907   CALL   OOPS
07A0 C37507   JMP    DIGIT2

;
;
;
; ROUTINE TO RETRIEVE CHARACTER FROM KEYBOARD
;
; KEY:
```



```

07A3 0E01
07A5 CD0500
07A8 C9

MVI C, 1H
CALL BDOS
RET

; ;
; ; ROUTINE PRINTS MESSAGE IF TOO MANY CHARACTERS
; ;
OOPS:
07A9 119B01
07AC 0E09
07AE CD0500
07B1 C9

LXI D, MSG4
MVI C, 9
CALL BDOS
RET

; ;
; ; DONE:
07B2 F1
07B3 11F104
07B6 0E09
07B8 CD0500
07BB CDA307
07BE FE4E
07C0 CAC907
U07C3 CD0000
07C6 C3E607

POP PSW
LXI D, MSG7
MVI C, 9H
CALL BDOS
CALL KEY
CPI 'N'
JZ GETMOR
CALL CRLF
JMP FLFILE

; DUMMY POP
; SEE IF USER WANTS
; FILE WRITTEN
; CHECK ANSWER
; IF NO, CONTINUE
; IF YES, GO WRITE

; ;
; ; GETMOR:
07C9 111405
07CC 0E09
07CE CD0500
07D1 CDA307
07D4 FE59
07D6 CADC07

LXI D, MSG8
MVI C, 9H
CALL BDOS
CALL KEY
CPI 'Y'
JZ RERUN

; SEE IF USER WANTS
; ANOTHER RUN
; CHECK ANSWER
; IF YES, GO BACK

; ; OTHERWISE, ITS TIME TO QUIT
; ;

```

```

07D9 C30000      EXIT:      JMP      0H          ;WARM BOOT
;
;SET UP FOR ANOTHER RUN
;
RERUN:
07DC 3A1201      LDA      FLNAME+5      ;INCREMENT FILE NAME
07DF 3C          INR      A
07E0 321201      STA      FLNAME+5
07E3 C39A06      JMP      BEGIN

;
;NEXT ROUTINE CREATES AND WRITES A DISK FILE -
;THE FIRST FILE RECORD CONTAINS INFORMATION
;WHICH WILL FACILITATE LATER RETRIEVAL OF THE
;DATA ---
;THE FIRST FILE RECORD CONTAINS THE DATA FILE
;NAME, FIRST CHANNEL, FINAL CHANNEL, SCAN RATE
;CODE LETTER, AND DATA POINTS CODE LETTER ---
;THE REMAINDER OF THE FIRST FILE RECORD IS ZEROES
;
;FLFILE:
;
;CREATE FILE ON DISK
;
07E6 0E13      MVI      C,      19      FLNAME
07E8 110D31      LXI      D,      BDOS
07EB CD0500      CALL     MVI      C,      22      FLNAME
07EE 0E16      LXI      D,      BDOS
07F0 110D01      CALL     CPI      255
07F3 CD0500      JZ      NOROOM
07F6 FEFF      XRA      A
07F8 CA6908      STA      FLNAME+32
07FB AF
07FC 322D01
;

```

```

;NEXT SET UP FIRST FILE RECORD
;
RECORD:
07FF 3E00      MVI A, 0H
0801 118009    LXI D, MEMORY-80H
0804 0680      MVI B, 80H      ;ZERO OUT RECORD

RLOOP:
0806 12        STAX D
0807 13        INX D
0808 05        DCR B
0809 C20608    JNZ RLOOP

;
;FILL IN FILE RECORD DATA
;
080C 010E01    LXI B, FLNAME+1
080F 118009    LXI D, MEMORY-80H
0812 2605      MVI H, 5H

RLOOP2:
0814 0A        LDAX B
0815 12        STAX D
0816 03        INX B
0817 13        INX D
0818 25        DCR H
0819 C21408    JNZ RLOOP2

;
;COPY FIRST 5 LETTERS
;OF FILE NAME INTO
;RECORD

;FIRST CHANNEL
;FINAL CHANNEL
;SCAN RATE CODE
;DATA POINT CODE

081C 3A0401    LDA ACHAN
081F 12        STAX D
0820 13        INX D
0821 3A0501    LDA BCHAN
0824 12        STAX D
0825 13        INX D
0826 3A0A01    LDA RCOUNT
0829 12        STAX D
082A 13        INX D
082B 3A0B01    LDA PCOUNT
082E 12        STAX D

```

```

; FIRST FILE RECORD NOW CONTAINS APPROPRIATE INFORMATION
;
;
; SINCE DMA PUT PAIRS OF DATA BYTES INTO MEMORY IN REVERSE
; ORDER, WANT TO REVERSE THEM BEFORE WRITING ON DISK
;
FLIP:
    LDA LIMIT
    LXI H, H
    ; UPPER LIMIT ON MEMORY USED
    ; BEGINNING OF DATA
    ;
FLOP:
    MOV B, B
    INX H
    M
    ; GET LSB
    MOV C, C
    MOV M, M
    B
    ; GET MSB
    DCX H
    MOV M, M
    C
    ; PUT LSB
    INX H
    INX H
    H
    ; PUT MSB
    CMP H
    JNZ FLOP
    ; CHECK AGAINST LIMIT
    ;
; DATA PAIRS NOW IN CORRECT ORDER
;
;
; READY TO START WRITING ONTO DISK
;
FWRITE:
    LXI D, D
    MEMORY-80H
    ; INFO RECORD
    ;
FLOOP:
    PUSH D
    MVI C, 26
    CALL BDOS
    ; SAVE POINTER
    ;
    ; CHANGE BUFFER ADDRESS

```

082F 3A3C01  
0832 21000A  
  
0835 46  
0836 23  
0837 4E  
0838 70  
0839 2B  
083A 71  
083B 23  
083C 23  
083D BC  
083E C23508  
  
0841 118029  
  
0844 D5  
0845 0E1A  
0847 CD0500





```

0885 110D01
0888 0E10
088A CD0500
088D C3C907

; IF ERROR OCCURRED IN WRITING ON DISK, ANOTHER WRITE SHOULD
; BE ATTEMPTED ON ANOTHER DISK
;
; WHENEVER DATA WRITE IS COMPLETED, NEED TO CLOSE FILE
;
CLOSE:
    LXI    D,    FLNAME
    MVI    C,    16
    CALL   BDOS
    JMP     GETMOR
;CHECK WITH USER

;
;
;
;
;
;*****
END 100H
0890

```

# APPENDIX K

## PATCH FOR CP/M BIOS PROGRAM

```

;PATCH TO CP/M BIOS PROGRAM
;
;ALTERS JUMP VECTOR BY READDRESSING JUMPS TO
;THE LIST OUT (LO) DEVICE.
;JUMP VECTOR INSTEAD POINTS TO ALTERNATE ROUTINE
;WHICH SENDS CHARACTER TO MODEL 40 PRINTER.
;PRINTER MUST HAVE BEEN PREVIOUSLY SET UP
;BY AN INDEPENDENT ROUTINE (ON.COM)
;

```

```

BE00 C344BE
BE03 C354BE
BE06 C3F2BE
BE09 C3F5BE
BE0C C3FBBE
BE0F C3E7BF
BE12 C301BF
BE15 C304BF
BE18 C307BF
BE1B C30CBF
BFE7

```

```

JMP BOOT
JMP WBOOT
JMP CONST
JMP CONIN
JMP CONOUT
JMP PATCH
JMP PUNCH
JMP READER
JMP HOME
JMP SELDSK
JMP ØBFE7H
JMP ORG

```

PATCH:

```

BFE7 DB63
BFF9 E601
BFEB CAE7BF
BFEE 79
BFEF D362
BFF1 C9

```

```

IN 63H ;CHECK USART STATUS
ANI 1
JZ PATCH
MOV A,C ;PUT BYTE IN ACCUM
OUT 62H ;SEND TO USART
RET

```

# APPENDIX L

## ON ASSEMBLY PROGRAM

```

;THIS ROUTINE INITIALIZES THE INTEL SBC 534 BOARD,
;THE TIMER, AND THE USART NEEDED TO DRIVE THE
;MODEL 40 PRINTER
;

```

0100

```

ORG 100H

```

```

;BASE ADDR OF 534 BOARD 60H
;CMD ADDR OF PRINTER USART 63H
;DATA ADDR OF PRINTER USART 62H
;

```

START:

0100 310002  
0103 D36F  
0105 D36C

```

LXI SP, 200H
OUT 6FH
OUT 6CH

```

```

;SET UP STACK
;RESETS 534 BOARD
;SELECTS CONTROL BLOCK

```

TIMER:

0107 3E76  
0109 D363  
010B 3E08  
010D D361  
010F 3E00  
0111 D361

```

MVI A, 76H
OUT 63H
MVI A, 8H
OUT 61H
MVI A, 0H
OUT 61H

```

```

;SELECT TIMER 1 FOR
;PRINTER USART --
;SET N=8 IN TIMER 1
;CCLK/N = 153.6KHZ FOR 9600
;BAUD, BR = 16X

```

USART:

0113 D36D

```

OUT 6DH

```

```

;SELECT DATA BLOCK

```

```

;MODE WORD - SETS UP 1 STOP BIT, ODD PARITY
;ENABLED, 7 BIT WORD, AND A BAUD RATE
;FACTOR OF 16X

```



# APPENDIX M

## REDUCE FORTRAN PROGRAM

```

C ** FOURIER COEFFICIENT DETERMINATION **
C * PROGRAM INPUT CONSISTS OF CHANNELS "J1" TO "JMAX" OF
C DISCRETIZED DATA USING A COMMON TIME BASE FOR THE SAMPLINGS.
C * PROGRAM OUTPUT CONSISTS OF FOURIER COEFFICIENTS FOR THE
C VARIOUS CHANNELS, INCLUDING OPTIONS FOR HIGHER HARMONICS.
C RELATIVE PHASING BETWEEN THE CHANNELS IS OBTAINED.
C
      DIMENSION Y(5),RMS(5),A(5,5),B(5,5),C(5,5),PHI(5,5),IX(5,500)
      1,X(5,500)
      1 FORMAT (1H0,'ENTER DISK FILE NUMBER (12)')//
      2 FORMAT (12)
      3 FORMAT (1H0,'ENTER FILE NO. (12), NUMBER OF CHANNELS (12), SCAN')
      4 FORMAT (1H,'RATE (15), FUNDAMENTAL FREQUENCY (F6.0), NUMBER')
      5 FORMAT (1H,'OF DATA POINTS (15), COORDINATION NUMBER (18)')//
      6 FORMAT (2I2,15,F6.0,15,18)
      7 FORMAT (1H0)
      8 FORMAT (424)
      9 FORMAT (5X,I4,4(5X,F8.5))
      11 FORMAT (1H1,'DATA',12,/)
      12 FORMAT (1H,15,'DATA POINTS')//
      13 FORMAT (1H,'SCAN RATE',15,'HERTZ')//
      14 FORMAT (1H,'COORDINATION NUMBER',18,/)
      J1 = 1
      JMAX = 1
      IDISK = 1
      IRATE = 1
      ICOORD = 000
      F1 = 1.
      IFNAME = 1
      PI = 3.141592654
      WRITE (6,1)

```



```

C      READ (5,2) IDISK
C      WRITE (6,3)
C      WRITE (6,4)
C      WRITE (6,5)
C      READ (5,6) IFNAME,JMAX,IRATE,F1,IR,ICOORD

C      ** TRUNCATE DATA SET TO INTEGER NO. OF FUNDAMENTAL PERIODS **
C      IR = NO. OF DATA RECORDS (OPTION SELECTABLE)
C      J1 = INITIAL DATA CHANNEL IDENT.
C      JMAX = FINAL DATA CHANNEL IDENT. (JMAX .GE.1 AND .LE.16)
C      F1 = FUNDAMENTAL FREQUENCY (HZ)
C      DELT = SAMPLE TIME FOR A DATA CHANNEL (SEC)
C      ICOORD= COORDINATION NO.
C      IP = INTEGER NO. OF FUNDAMENTAL PERIODS
C      M = INTEGER NO. SAMPLES FOR EACH CHANNEL (TRUNCATED FORM)
C      N = IR/JMAX
C      AN = N
C      RATE = IRATE
C      DELT = 1./RATE
C      IP = IFIX(AN*F1*DELT)
C      AP = IP
C      M = IFIX(AP/(F1*DELT))

C      NEXT READ IN SAMPLED DATA FROM DISK FILE
C      DO 30 I = 1,M
C          READ (IDISK,8) (IX(J,I), J = J1,JMAX)
C      30 CONTINUE

C      SCALE INTEGER DATA AND CONVERT TO REAL NUMBERS
C      DO 40 I = 1,M
C          DO 35 J = J1,JMAX
C              IF (IX(J,I).GT.2047) GO TO 32
C              AAA = IX(J,I)
C              GO TO 33

```

```

32      AAA = IX(J,I) - 65536
33      CONST = 5./2047.
      X(J,I) = CONST * AAA
35      CONTINUE
40      CONTINUE

      ECHO SCALED DATA VALUES TO CONSOLE

      WRITE (6,7)
      WRITE (6,11) IFNAME
      WRITE (6,12) IR
      WRITE (6,13) IRATE
      WRITE (6,14) ICOORD
      DO 45 I = 1,20
      WRITE (6,9) (I,X(J,I), J=J1,JMAX))
45      CONTINUE

C
C
C
C
C ** FIND CHANNEL BIAS AND R.M.S. **
      Y(J) = AVE. VALUE OF CHANNEL "J"
      RMS(J) = RMS VALUE OF CHANNEL "J"
C ** REMOVE BIAS FROM DATA **
50      DO 59 J=J1,JMAX
      AVE = 0.0
51      DO 52 I=1,M
      AVE = AVE + X(J,I)
52      CONTINUE
      AM = M
      Y(J) = (1./AM)*AVE
      X2 = 0.0
53      DO 54 I=1,M
      X(J,I) = X(J,I) - Y(J)
      X2 = X2 + X(J,I)**2
54      CONTINUE
      X2 = (1./AM)*X2

```

```

RMS(J) = SQRT(X2)
59 CONTINUE
65 WRITE(6,1000) J1,JMAX,ICoord
   WRITE(6,1001) IR,DELT,F1
   WRITE(6,1002) M,N
   WRITE(6,1003)
70 DO 71 I=J1,JMAX
   WRITE(6,1010) I,Y(I),RMS(I)
71 CONTINUE
C ** FOURIER COEFFICIENT EVALUATION BRANCH **
C   KMAX = MAX. HARMONIC DESIRED
C   DELTAU = INTERCHANNEL SAMPLE DELAY (SEC)
C   X(J,I) = DATA ARRAYS (D.C. BIAS REMOVED)
C   J = DATA CHANNEL, J1 TO JMAX
C   I = DISCRETIZED SAMPLE INDEX, I=1 TO M
100 DELTAU = 0.
   KMAX = 2
110 DO 123 K=1,KMAX
   AK = K
   ARG = 2.*PI*F1*AK*DELT
   S1 = SIN(ARG)
   C1 = COS(ARG)
115 DO 122 I=J1,JMAX
   AI = (I-1)
   ARG = 2.*PI*F1*AK*(DELT + (AI*DELT))
   S2 = SIN(ARG)
   C2 = COS(ARG)
   A(K,I)=0.0
   B(K,I)=0.0
120 DO 121 L=1,M
   A(K,I)= A(K,I) + X(I,L)*C2
   B(K,I)= B(K,I) + X(I,L)*S2
   AC2 = C2*C1 - S2*S1
   AS2 = S2*C1 + C2*S1
   C2 = AC2
   S2 = AS2

```

```

121 CONTINUE
   AM = M
   A(K,I) = (2./AM)*A(K,I)
   B(K,I) = (2./AM)*B(K,I)
   C(K,I) = SQRT(A(K,I)**2 + B(K,I)**2)
   A1 = ABS(A(K,I))
   B1 = ABS(B(K,I))
   IF(A1.LT.0.001.AND.B1.LT.0.001) GO TO 200
   PHI(K,I) = ATAN2(-B(K,I),A(K,I))*(180./PI)
   GO TO 125
200 PHI(K,I) = 0.0
125 CONTINUE
122 CONTINUE
123 CONTINUE
130 DO 137 K=1,KMAX
   WRITE(6,1020) K
135 DO 136 I=J1,JMAX
   WRITE(6,1025) I,A(K,I),B(K,I),PHI(K,I),C(K,I)
136 CONTINUE
137 CONTINUE
1000 FORMAT (1H1,4X,16HINITIAL CHANNEL:,T25,I2/7X,14HFINAL CHANNEL:,
1 T25,I2/ 7X,14HCOORD. NUMBER:,T25,I8,/)
1001 FORMAT(3X,18HTOTAL NO. SAMPLES:,T25,I5/
1 2X,19HSCAN PERIOD (SEC.):,T25,E11.4/1X,20HREFERENCE FREQ (HZ):,
2 T25,E11.4//)
1002 FORMAT(1X,20HDATA PTS./CH., USED:,T25,I4,T35,7HAVAIL.:,T45,I4//)
1003 FORMAT(5X,'SIGNAL BIAS AND R.M.S. VALUES',/
1 2X,'CHANNEL',T15,'BIAS',T23,'R.M.S.',/)
1010 FORMAT(4X,I2,T12,F7.4,T22,F7.4)
1020 FORMAT(1H0,4X,'FOURIER COEFFICIENTS FOR HARMONIC',I3/
1 2X,'CHANNEL',T14,'COS',T24,'SIN',T34,'PHASE',T44,'MAG')
1025 FORMAT(4X,I2,T12,F7.4,T22,F7.4,T32,F7.2,T42,F7.4)
500 FORMAT (1H0,2X,'INDEX',T13,'X(1,I)',T23,'X(2,I)',/)
501 FORMAT (4X,I3,T12,F7.4,T22,F7.4)
      STOP
      END

```

# APPENDIX N

DATA 3				
1024 DATA POINTS				
SCAN RATE 300 HERTZ				
COORDINATION NUMBER 911001				
1	1.10650	1.09673	1.09428	1.08207
2	-0.05862	-0.06839	-0.07328	-0.08305
3	-1.21641	-1.22374	-1.23351	-1.23840
4	-2.14704	-2.15437	-2.15681	-2.16170
5	-2.69419	-2.69419	-2.69663	-2.69663
6	-2.76991	-2.76746	-2.76746	-2.76746
7	-2.36688	-2.36444	-2.35955	-2.35466
8	-1.53639	-1.52907	-1.52418	-1.51685
9	-0.42013	-0.41280	-0.40547	-0.39814
10	0.75721	0.76453	0.77186	0.77919
11	1.82218	1.82706	1.83195	1.83928
12	2.56961	2.57206	2.57694	2.57938
13	2.86517	2.86517	2.86517	2.86517
14	2.69907	2.69663	2.69419	2.69174
15	2.06400	2.05911	2.05178	2.04690
16	1.07474	1.06986	1.06253	1.05520
17	-0.09282	-0.09770	-0.10747	-0.11480
18	-1.24572	-1.25061	-1.26038	-1.26771
19	-2.16903	-2.17391	-2.17880	-2.18124
20	-2.70151	-2.70396	-2.70640	-2.70640



INITIAL CHANNEL: 1  
 FINAL CHANNEL: 4  
 COORD. NUMBER: 911001

TOTAL NO. SAMPLES: 1024  
 SCAN PERIOD (SEC.): 0.3333E-02  
 REFERENCE FREQ (HZ): 0.2000E 02

DATA PTS./CH., USED: 255 AVAIL.: 256

SIGNAL BIAS AND R.M.S. VALUES

CHANNEL	BIAS	R.M.S.
1	0.0445	2.0098
2	0.0444	2.0098
3	0.0444	2.0098
4	0.0442	2.0099

FOURIER COEFFICIENTS FOR HARMONIC 1

CHANNEL	COS	SIN	PHASE	MAG
1	1.8424	-2.1585	49.52	2.8379
2	1.8367	-2.1634	49.67	2.8379
3	1.8308	-2.1685	49.83	2.8380
4	1.8249	-2.1735	49.98	2.8381

FOURIER COEFFICIENTS FOR HARMONIC 2

CHANNEL	COS	SIN	PHASE	MAG
1	-0.0034	0.0091	-110.30	0.0097
2	-0.0031	0.0091	-108.86	0.0097
3	-0.0030	0.0092	-108.40	0.0096
4	-0.0031	0.0088	-109.56	0.0093

DATA 4

1024 DATA POINTS

SCAN RATE 3000 HERTZ

COORDINATION NUMBER 911002

1	-1.93698	-1.99804	-2.05178	-2.10308
2	-2.59648	-2.62335	-2.65022	-2.67465
3	-2.80166	-2.79922	-2.79433	-2.78700
4	-2.52565	-2.49389	-2.45725	-2.42062
5	-1.80019	-1.73913	-1.68051	-1.61700
6	-0.74499	-0.67171	-0.59599	-0.51783
7	0.42990	0.50562	0.58378	0.65950
8	1.54861	1.61456	1.68051	1.73913
9	2.40107	2.44260	2.48168	2.51832
10	2.83097	2.84074	2.85051	2.85540
11	2.78945	2.76991	2.75037	2.72594
12	2.28139	2.23253	2.18124	2.12750
13	1.37763	1.30923	1.23840	1.16756
14	0.23449	0.15633	0.08061	0.00244
15	-0.93307	-1.00879	-1.07963	-1.15535
16	-1.94187	-1.99804	-2.05178	-2.10308
17	-2.59892	-2.62579	-2.65266	-2.67709
18	-2.80166	-2.79922	-2.79433	-2.78700
19	-2.52076	-2.49145	-2.45481	-2.41573
20	-1.79531	-1.73669	-1.67318	-1.60967

INITIAL CHANNEL: 1  
 FINAL CHANNEL: 4  
 COORD. NUMBER: 911002

TOTAL NO. SAMPLES: 1024  
 SCAN PERIOD (SEC.): 0.3333E-03  
 REFERENCE FREQ (HZ): 0.2000E 03

DATA PTS./CH., USED: 255 AVAIL.: 256

# SIGNAL BIAS AND R.M.S. VALUES

CHANNEL	BIAS	R.M.S.
1	0.0369	2.0113
2	0.0362	2.0116
3	0.0357	2.0114
4	0.0353	2.0112

## FOURIER COEFFICIENTS FOR HARMONIC 1

CHANNEL	COS	SIN	PHASE	MAG
1	-1.0177	-2.6559	110.97	2.8442
2	-1.0901	-2.6274	112.53	2.8445
3	-1.1613	-2.5964	114.10	2.8443
4	-1.2314	-2.5636	115.66	2.8440

## FOURIER COEFFICIENTS FOR HARMONIC 2

CHANNEL	COS	SIN	PHASE	MAG
1	0.0030	0.0011	-19.56	0.0032
2	0.0036	0.0009	-14.15	0.0037
3	0.0040	0.0000	-0.64	0.0040
4	0.0041	-0.0009	12.82	0.0042

DATA 5

1024 DATA POINTS

SCAN RATE 10000 HERTZ

COORDINATION NUMBER 911003

1	-1.21641	-1.59013	-1.89301	-2.16658
2	-2.48656	-2.63801	-2.74792	-2.80410
3	-2.78700	-2.70640	-2.57694	-2.40596
4	-2.02247	-1.73669	-1.41426	-1.06253
5	-0.45921	-0.07084	0.31265	0.69370
6	1.28236	1.62677	1.92721	2.19834
7	2.54274	2.69907	2.80410	2.85295
8	2.84074	2.76258	2.63556	2.46214
9	2.06109	1.79775	1.47289	1.12115
10	0.52760	0.14411	-0.23449	-0.62531
11	-1.21397	-1.55349	-1.85882	-2.13727
12	-2.48412	-2.63556	-2.74792	-2.80166
13	-2.78700	-2.70884	-2.57938	-2.40840
14	-2.02491	-1.73913	-1.41671	-1.06497
15	-0.46165	-0.07815	0.30288	0.68637
16	1.27992	1.61700	1.92233	2.19101
17	2.54274	2.69663	2.80410	2.85540
18	2.84074	2.76258	2.63556	2.46458
19	2.08598	1.79775	1.47777	1.12848
20	0.53493	0.13679	-0.24426	-0.62531

INITIAL CHANNEL: 1  
 FINAL CHANNEL: 4  
 COORD. NUMBER: 911003

TOTAL NO. SAMPLES: 1024  
 SCAN PERIOD (SEC.): 0.1000E-03  
 REFERENCE FREQ (HZ): 0.1000E 04

DATA PTS./CH., USED: 250 AVAIL.: 256

# SIGNAL BIAS AND R.M.S. VALUES

CHANNEL	BIAS	R.M.S.
1	0.0313	2.0130
2	0.0318	2.0129
3	0.0319	2.0130
4	0.0316	2.0127

# FOURIER COEFFICIENTS FOR HARMONIC 1

CHANNEL	COS	SIN	PHASE	MAG
1	0.5409	-2.7947	79.05	2.8465
2	0.1554	-2.8422	86.87	2.8464
3	-0.2294	-2.8373	94.62	2.8465
4	-0.6140	-2.7792	102.46	2.8462

# FOURIER COEFFICIENTS FOR HARMONIC 2

CHANNEL	COS	SIN	PHASE	MAG
1	0.0040	0.0017	-22.64	0.0044
2	0.0029	0.0005	-9.73	0.0030
3	0.0031	-0.0013	22.81	0.0033
4	0.0040	-0.0027	33.41	0.0048



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